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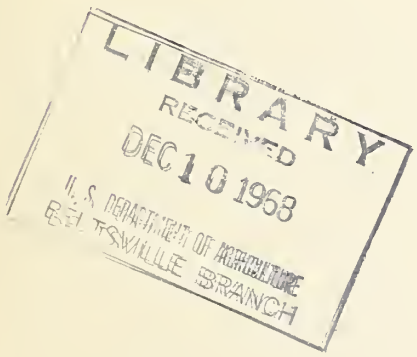
SAMPLING OF WHEAT, SOYBEANS, AND CORN TRANSPORTED IN COVERED HOPPER CARS

(A Progress Report)



UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

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Cargill, Inc., supplied grain and elevators at Minneapolis, Denver, and Omaha, and the Prob-A-Vac sampler. It also provided two men from its grain research staff. These men accompanied the shipments to Denver and Omaha to expedite the research at those elevators.

Through cooperation of Pullman-Standard, a division of Pullman Incorporated, and the Great Northern Railway, three hopper cars of the Great Northern Railway were used for this research.

Seven railroads hauled and switched the cars:

Chicago and North Western Railway Company
Chicago, Burlington & Quincy Railroad Company
Chicago Great Western Railway Company
Chicago, Milwaukee, St. Paul and Pacific Railroad Company
Chicago, Rock Island and Pacific Railroad Company
The Denver and Rio Grande Western Railroad Company
Union Pacific Railroad Company

The Denver Equipment Company, Gamet Manufacturing Company, Gustafson Manufacturing Company, and Strand Manufacturing Company supplied diverter-type mechanical samplers; and employees of these companies operated their samplers.

The Grain Division, Consumer and Marketing Service, U.S. Department of Agriculture, supplied the belt-type (Woodside-type, Woodside-type modified, and Ellis cup), the pelican, and the probe-type (12-foot barge and pneumatic) samplers used in this research. Grain Division employees installed the belt-type samplers and operated all samplers supplied by the Division. All the samples drawn were analyzed at the Minneapolis laboratory of the Grain Division.

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Sampling of Wheat, Soybeans, and Corn Transported in Covered Hopper Cars

(A Progress Report)

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SUMMARY

Three 160,000-pound lots of wheat, soybeans, and corn were loaded into covered hopper cars at Minneapolis and were transported to Denver and Omaha and back to Minneapolis. At each city, the grains were unloaded and reloaded into the hopper cars. The lots were sampled during loading, after loading, before unloading, and during unloading.

Diverter-type mechanical samplers (Denver, Gamet, Gustafson, and Strand), belt-type mechanical samplers (Woodside-type and Woodside-type modified), a belt-type manual sampler (Ellis cup), probe-type samplers (12-foot barge, pneumatic, and Prob-A-Vac), and a pelican sampler were used to draw the samples.

The diverter-type mechanical samplers generally were more accurate than the other samplers used in this research. A probable reason is that the diverters removed nearly a complete cross-section of the grain stream during each traverse of the stream.

The pelican sampler had approximately the same accuracy and variability as the diverters. But there were indications that at higher grain-flow rates, the pelican began to overflow before traversing the entire grain stream. This could cause a bias in the sample if the components of the grain stream were stratified.

The belt-type mechanical and manual samplers had about the same accuracy and variability as the diverters except when sampling screenings in the soybean lot. The reason for this could be that the screenings sifted to the bottom on the belt and were not picked up by the sampling cups. Samplers of this type sample only a part of the grain stream a part of the time and therefore may be biased by stratification of components of the grain stream flowing past the sampler.

Comparisons were made of the performances of mechanical samplers with diverter slots 0.50 and 0.75 inches wide and with diverters traversing the grain stream at 100 and 200 feet per minute. These slot widths and velocities had no marked effect on sample accuracy or variability, except that during loading of the soybean lot at Minneapolis, the samples drawn with the 0.50-inch-wide slot contained significantly more screenings than samples drawn with the 0.75-inch-wide slot.

Samples drawn by the barge probe, pneumatic sampler, and Prob-A-Vac were unsatisfactory for estimating screenings in the soybean lot and caused overestimates of screenings in the wheat lot. But the estimates of screenings in the corn lot were good.

These findings apply to grain lots with the specific compositions used in this research. The percentages of added components exceeded normal levels found in market channels. Probably all the samplers would perform better when sampling cleaner grain.

INTRODUCTION

Previous research[1] compared the performance of three diverter-type mechanical samplers and the pelican while drawing samples from wheat flowing at rates up to about 5,000 pounds per minute. The diverters in those samplers had a slot width of 0.75 inch and a velocity of 100 feet per minute. Data on the effects of grain-flow rate, slot width, and velocity on the performance of diverter-type samplers are needed to establish standards for their manufacture, installation, and operation.

Objectives of this research were to evaluate the performance of (1) samplers with diverter slots 0.50 and 0.75 inch wide and velocities of 100 and 200 feet per minute, (2) large diverter-type samplers used in grain terminals to sample grain at flow rates up to about 40,000 pounds per minute, (3) belt-type mechanical samplers, (4) the pelican sampler, and (5) probe-type samplers used to draw samples from grain at rest in large covered hopper cars. Corn, wheat, and soybean lots were used.

The research reported here is part of a continuing Market Quality Research Division effort to determine grain-flow characteristics and their relation to the requirements and performance of mechanical grain samplers.

PROCEDURE

Facilities

The research covered in this report was conducted at three grain elevators located at Minneapolis, Minn., Denver, Colo., and Omaha, Nebr. The layout of the bins and the conveying and other equipment for the elevators are shown in figures 1 to 3.

The grain used in the research was transported between the three elevators in three covered hopper cars. The hopper cars (GN171532, GN171533, and GN171534) each had a capacity of 4,740 cubic feet (figs. 2 and 3).

Lot Composition and Makeup

Quantities of 160,000 pounds each of wheat, soybeans, and corn were used, as this is the minimum quantity normally loaded into a large hopper car. The elevator bins at Minneapolis had a capacity of about 45,000 pounds each; therefore, four bins were required to hold a 160,000-pound lot.

The wheat lot was prepared by loading each of four bins with 36,000 pounds of wheat in the bottom, 2,000 pounds of screenings in the middle, and 2,000 pounds of corn on top. The soybean lot was prepared by loading each of four bins with 38,000 pounds of soybeans in the bottom, and 2,000 pounds of screenings on top. Each of four bins were loaded with 38,000 pounds of corn in the bottom and 2,000 pounds of wheat on top. Care was taken to insure that each group of four bins contained the same weight of grain with its components arranged in the same manner.

Moisture and test weight for the components of the lots were as follows:

Lot and components	Moisture Percent	Test weight Lb./bu.
Wheat lot:		
Wheat	9.5	62.0
Corn	10.8	60.8
Screenings	--	59.8
Corn lot:		
Wheat	10.8	63.7
Corn	13.3	54.8
Soybean lot:		
Soybeans	9.4	57.3
Screenings	--	55.1

Sampling Devices

Three diverter-type mechanical samplers (Gamet, Gustafson, and Strand) were used at Minneapolis. (A sketch of a typical diverter-type mechanical grain sampler is shown in figure 4.) They were the same samplers described in the previous report.[2] The diverter

[1] Kramer, H. A. Performance of three diverter-type mechanical grain samplers and the pelican. U.S. Dept. Agr. ARS 51-16, 40 pp., 1968.

[2] See footnote 1.

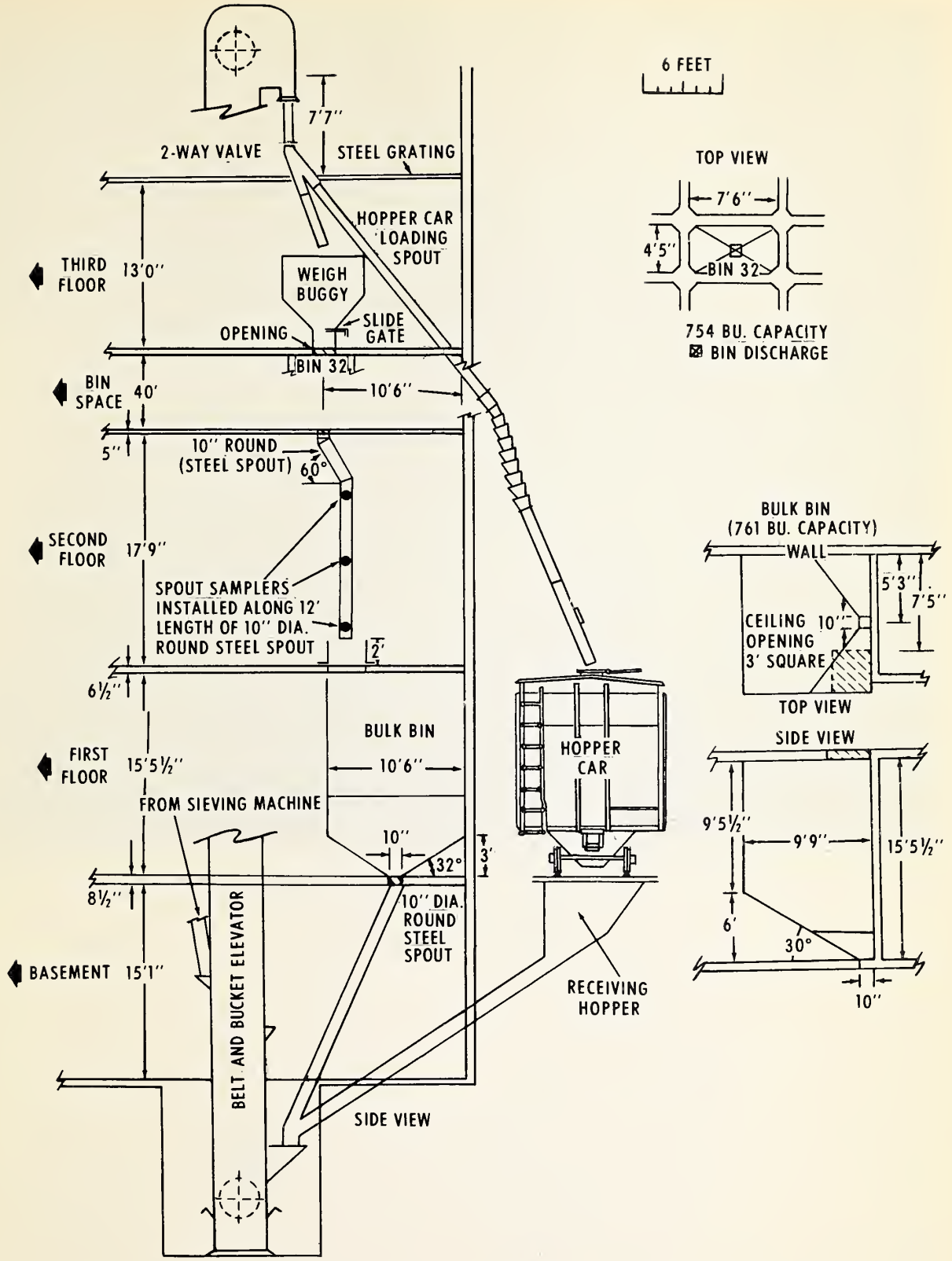

Figure 1.--Layout of bins, conveying equipment, and other facilities at Minneapolis grain elevator.

Figure 2.--Elevator in Denver where grain was unloaded from hopper cars, elevated to a hopper scale, weighed, and sampled during reloading.

Figure 3.--Hopper car loading spout at Omaha elevator.

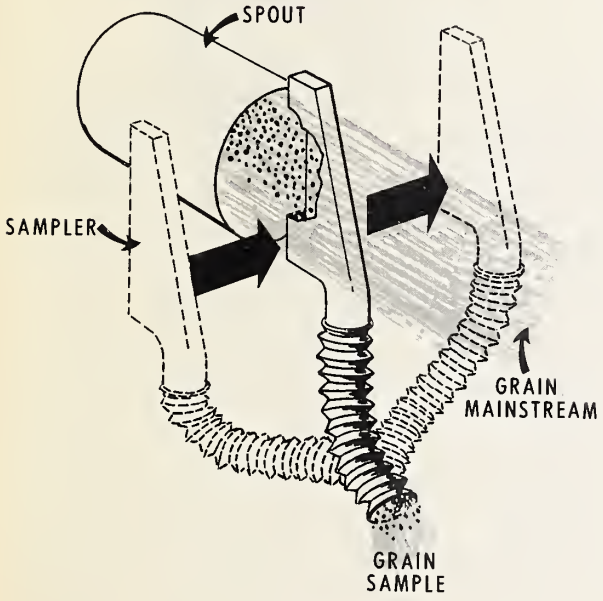

Figure 4.--Operating principle of diverter-type sampler.

slot width and the velocity of each sampler were adjusted to 0.50 or 0.75 inch ± 0.031 inch and 100 or 200 feet per minute ± 5 percent. Sampling interval was adjusted to 30 or 60 seconds ± 10 percent. The three samplers were positioned along a 10-inch-diameter vertical spout with the Gamet on top, the Strand in the middle, and the Gustafson below (fig. 5). Electric timers actuated the samplers at predetermined intervals. A pelican sampler (not shown) was used at lower end of the spout.

A large diverter-type mechanical sampler (Denver, serial SW82965-1, type Auto., size 24 inch) was used at Denver. Its diverter slot width was 0.75-inch and the velocity was 86 feet per minute. This primary sampler is the size used at large terminal elevators. Figure 6 shows it installed along a vertical 15-inch-diameter round spout leading from a distributor to a hopper car below. Figure 6 also shows the secondary mechanical sampler (Vezin-type, serial TW86837-1, size 20 with a 1.25-inch diverter slot rotating at 29 revolutions per minute) used to reduce samples drawn by the large primary sampler.

A large diverter-type mechanical sampler (Strand) was used at Omaha. Its diverter slot width was 0.75 inch and the velocity was 100 feet per minute. This primary sampler is the size used at large terminal elevators. Figures 7 and 8 show it installed along the loading spout leading from a garner bin to a hopper car below. Figure 8 also shows the secondary sampler (Strand, reciprocating diverter-type with an adjustable diverter slot set at 1.00 inch width) used to reduce samples drawn by the large primary sampler.

Also at Omaha, two Woodside-type samplers and a manually operated Ellis sampler drew samples from a belt, which conveyed grain horizontally from the hopper car unloading pit to an elevator leg. One Woodside-type sampler was modified so that its sampling cups would alternately dip into the upper and lower portions of the grain stream being conveyed by the belt. Figure 9 shows a Woodside-type sampling soybeans.

An official pelican sampler (fig. 10) was used to sample grain being loaded into the hopper cars at Minneapolis and at Denver. The

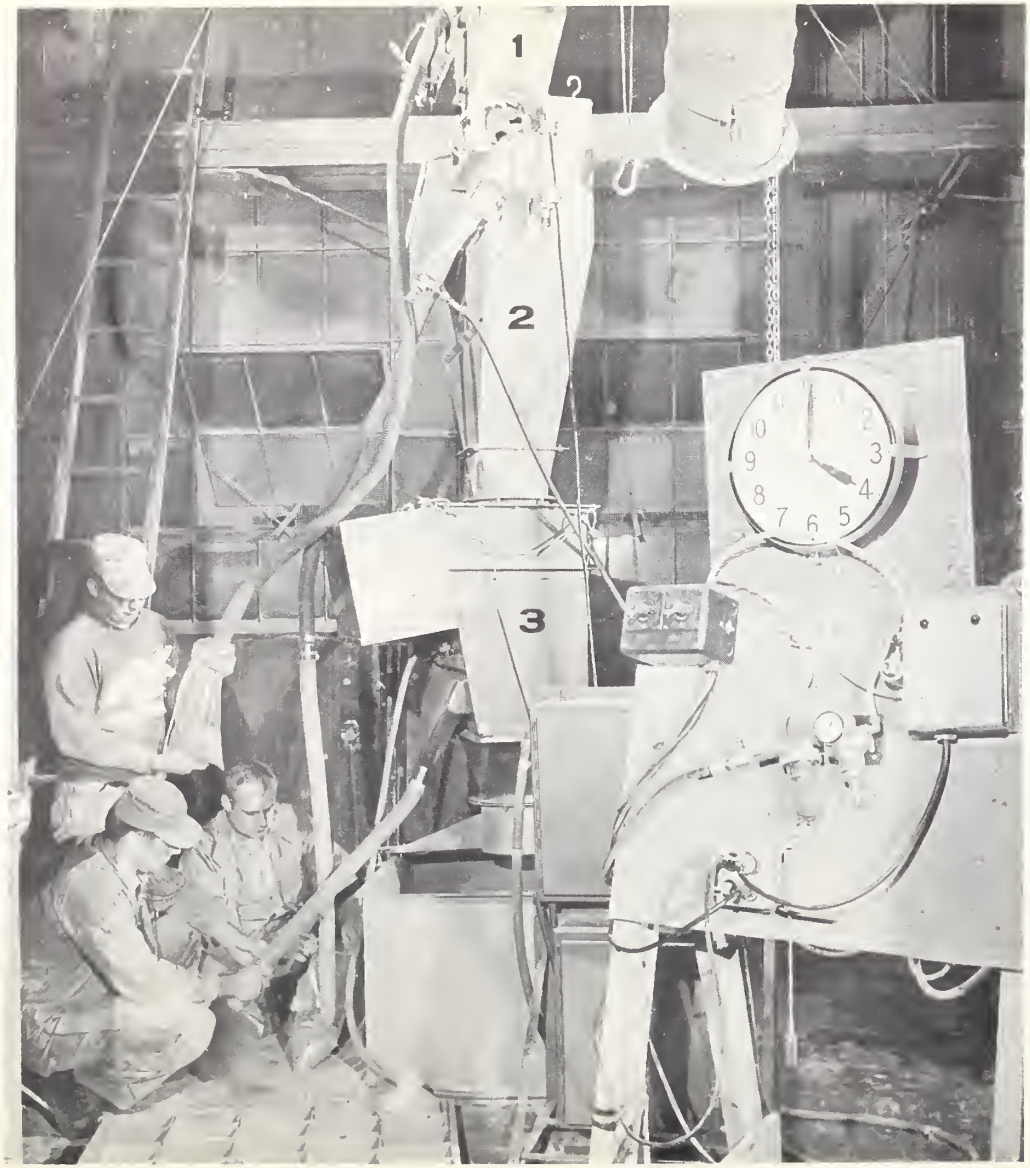

Figure 5.--Three diverter-type mechanical samplers in series each drew samples of grain flowing vertically from an upper to a lower bin. A pelican sampler (not shown) was used at lower end of spout.

Figure 6.--Diverter-type primary sampler (A) and a secondary sampler (B) installed in a 15-inch-diameter loading spout at Denver grain elevator.

Figure 7.--Diverter-type primary sampler installed in loading spout at Omaha grain elevator.

Figure 8.--Diverter-type primary sampler (A) and secondary sampler (B) used to draw samples of grain being loaded into hopper cars at Omaha grain elevator.

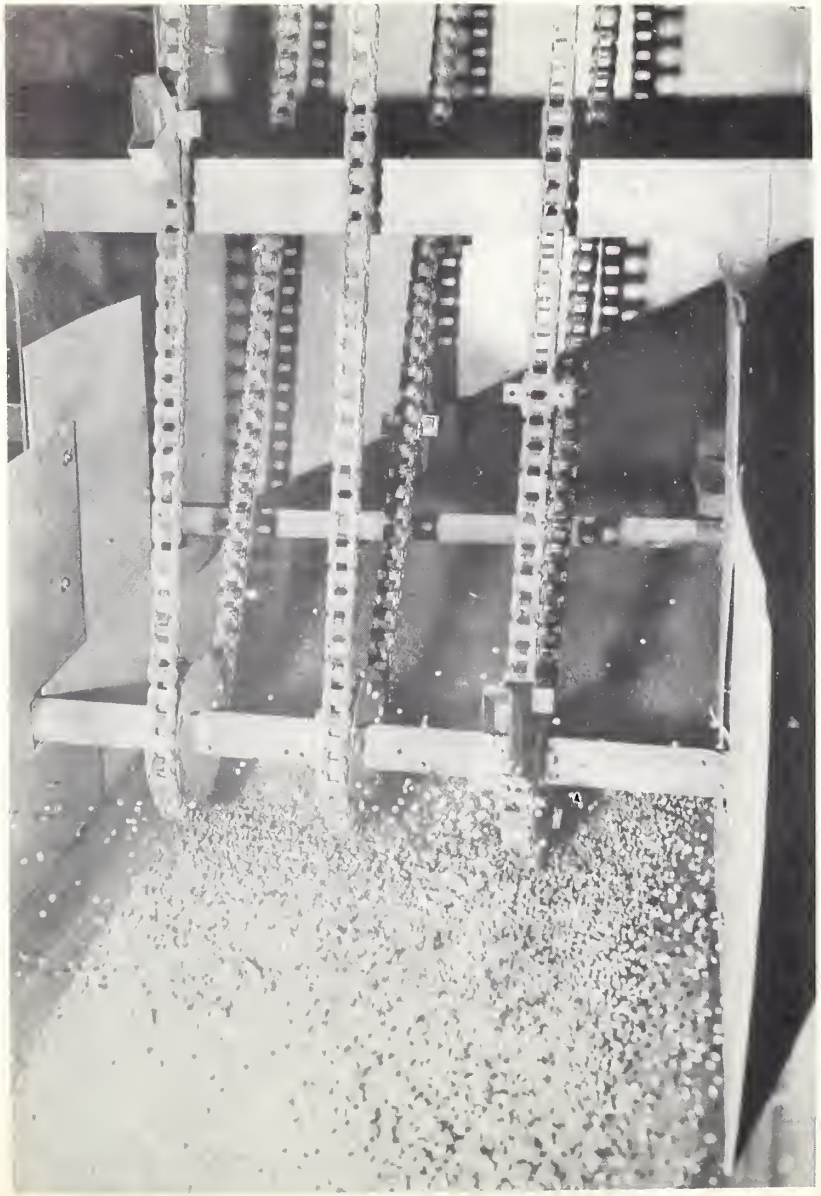

Figure 9.--Woodside-type sampler used to sample grain being unloaded by belt from hopper cars at Omaha grain elevator.

Figure 10.--Pelican sampler used to sample grain during loading into hopper cars at Minneapolis and Denver and during unloading of hopper cars at Minneapolis.

Figure 11.--12-foot barge probe used to sample grain while at rest in hopper cars.

pelican was also used at Minneapolis to sample grain being returned from the hopper cars to the elevator.

At Minneapolis, Denver, and Omaha, the grain was sampled (while at rest in the hopper cars) with 12-foot barge probe (fig. 11), a pneumatic probe of experimental design, and a commercially available Prob-A-Vac.

Sampling Procedure

The weight of an increment sample[3] drawn by a diverter traversing a grain stream is influenced by the diverter slot width and the velocity. A small, yet representative, increment is desired. In this research, the performances of diverters with 0.50- and 0.75-inch slot widths and velocities of 100 and 200 feet per minute were compared.

[3] An increment sample is the sample drawn during one traverse of a diverter (or pelican) through the grain stream.

At Minneapolis, four bins each of wheat, soybeans, and corn were prepared for sampling as described under Lot Composition and Makeup. The layered grain in each of the four bins of the three grain lots was spouted by gravity to a lower bin and then re-elevated to an upper bin. This treatment resulted in some mixing of the previously layered grain. Grain from the 12 bins was sampled by the three diverter-type mechanical samplers and the pelican sampler as it was loaded into covered hopper cars (one car each of wheat, soybeans, and corn). During loading, the mechanical samplers were used according to the statistical plan shown in table 1. This plan employed the 12 bins of grain and the following variables: two slot widths, two diverter velocities, and three grains. A sampling interval of 60 seconds was used, and the sampling sequence was adjusted so there was no interference between samplers. Pelican samples were drawn at 60-second intervals at the end of the bin discharge spout. Each

Table 1.--Statistical plan followed for comparing effect of different diverter slot widths and velocities

Grain and sampler	Bin A		Bin B		Bin C		Bin D	
	Slot width	Velocity	Slot width	Velocity	Slot width	Velocity	Slot width	Velocity
	Inch	Ft./min.	Inch	Ft./min.	Inch	Ft./min.	Inch	Ft./min.
Wheat:								
Gamet	0.75	100	0.50	200	0.50	100	0.75	200
Strand	.50	100	.75	200	.75	100	.50	200
Gustafson	.50	200	.50	100	.75	200	.75	100
Soybeans:								
Gamet	.50	100	.75	200	.75	100	.50	200
Strand	.50	200	.50	100	.75	200	.75	100
Gustafson	.75	100	.50	200	.50	100	.75	200
Corn:								
Gamet	.50	200	.50	100	.75	200	.75	100
Strand	.75	100	.50	200	.50	100	.75	200
Gustafson	.50	100	.75	200	.75	100	.50	200

Figure 12.--Increment samples of grain drawn by each of the three diverter-type samplers at Minneapolis were collected in plastic bags and labeled with sampling sequence.

increment sample was collected in a plastic bag. Figure 12 shows this operation.

After being loaded at Minneapolis with wheat, soybeans, and corn, the three hopper cars were taken to Denver. The grain was unloaded into the receiving pit of the terminal elevator shown in figure 2. The 160,000-pound lots of grain were elevated to a 100,000-pound-capacity hopper scale in two drafts of about 80,000 pounds each. After weighing, each draft was returned by gravity from the scale garner to the hopper car. During the return, the grain stream was sampled at 30-second intervals by a mechanical sampler along the 15-inch-diameter loading spout and by pelican sampler at the hopper car. Grain-flow rates of approximately 40,000 and 20,000 pounds per minute were used to measure the effect of this variable on both the accuracy and weight of samples drawn by the two samplers. Each increment sample was sealed in a plastic bag for individual analysis.

After being unloaded, reloaded, and sampled four times at Denver, the three hopper cars of grain were taken to Omaha. The grain was unloaded into the receiving pit of the terminal elevator (fig. 13). The cycles of handling and sampling were nearly the same as at Denver, except that a horizontal belt conveyed the grain from the receiving pit to an elevator leg. Belt sampling of each grain, in 80,000-pound drafts, was conducted along this belt (fig. 9). Composite samples[4] were drawn by each of two Woodside-type samplers and increment samples were drawn at 30-second intervals with a manually operated Ellis sampler.

After elevation to a 100,000-pound-capacity hopper scale, the 80,000-pound drafts were

[4] A composite sample is made up of distinct samples drawn separately and combined into one sample.

Figure 13.--Grain being unloaded into receiving pit of Omaha terminal elevator.

weighed and reloaded into their respective hopper cars. Samples were drawn at 30-second intervals by the Strand diverter-type sampler (figs. 7 and 8) during the reloading of each draft. The first and third loadings of each hopper car were at the normal high-flow rate for a terminal elevator; the second and fourth loadings were at about one-half the normal rate.

The arrangement of the loading spout at the hopper car was different at Omaha from that at Denver. Because of this difference, pelican samples could not be drawn at Omaha.

The three hopper cars of grain were returned to Minneapolis and unloaded into the receiving hopper of the originating elevator. Each grain flowed by gravity from the receiving hopper to an elevator leg. The elevated grain flowed by gravity to the same weigh buggy (fig. 1) used when the three 160,000-pound lots of grain were made up with their respective components. The weighed grain

flowed by gravity to the bin located above the vertical spout to which the three mechanical samplers were attached. These were the samplers used when the grain was loaded into the hopper cars (fig. 5). Each grain was sampled at 60-second intervals by the Gamet, Strand, Gustafson, and pelican samplers, in that order, as it flowed to storage bins. Slot widths and velocities for the diverters of the mechanical samplers were as follows:

Grain and sampler	Slot width Inch	Velocity Ft./Min.
Wheat:		
Gamet	0.50	200
Strand	.75	100
Gustafson	.50	100
Soybeans:		
Gamet	.75	100
Strand	.50	100
Gustafson	.50	200
Corn:		
Gamet	.50	100
Strand	.50	200
Gustafson	.75	100

At Denver and Omaha, both the cut-down portion and the larger portion of each sample drawn by the primary samplers were analyzed. These analyses were made to avoid bias to the primary sampler because of error in the secondary sampler. They also provided a measure of secondary sampler performance.

This research required the measurement of small differences in the weight of the grain and the added components in the three lots as well as an accurate sample analysis. Care was taken to avoid contributing errors, such as loss or addition of other grain or extraneous material to the lots. All grain bins, receiving pits, elevator legs, scale garners, and other equipment were thoroughly cleaned before and after use. The weights of all samples drawn from the lots were included in the calculations, and all samples were returned to their respective lots at the earliest feasible time after analysis.

The wheat, soybeans, and corn were sampled while at rest in the three hopper cars. Samples were drawn from the center of each of the three bays of each car using the three probes listed under Sampling Devices. The probes were inserted vertically to the lowest point of each bay in the following order:

Bay	Sampler sequence		
B	Pneumatic	Prob/A/Vac	Barge
C	Prob/A/Vac	Barge	Pneumatic
A	Barge	Pneumatic	Prob/A/Vac

To compare vertical versus vertical-plus-slant probing, additional samples were drawn with the 12-foot barge probe. The probe was inserted into the grain at a slant toward the end of each car (bays B and A) and toward one side of each bay. The bays and the pattern followed for inserting the probes for both the vertical and the vertical-plus-slant sampling are shown in figure 14.

Transportation of the grain between Minneapolis, Denver, Omaha, and return to Minneapolis provided an opportunity to investigate redistribution of components caused by vibration while in transit. The maximum depth of grain in each bay was about 10 feet. Samples were drawn by vertically probing at the deepest part of each bay and by sampling at two different depths to determine if the location of the components changed during transport. Samples from the top layer were drawn between a point 5 feet above the bottom of the bay and the surface of the grain. Samples from the bottom layer were drawn between a point 5 feet above the bottom of the bay and the bottom of the bay. The bottom portion was kept separate from its corresponding top portion, and each portion was analyzed separately. This sampling procedure was followed in probe sampling the grain in each hopper car (1) after loading and before transporting, and (2) before unloading and after transporting between elevators.

All grain samples drawn at Denver and Omaha were returned to Minneapolis in sealed plastic bags. This made it possible for one laboratory to analyze all the samples using the same equipment and personnel.

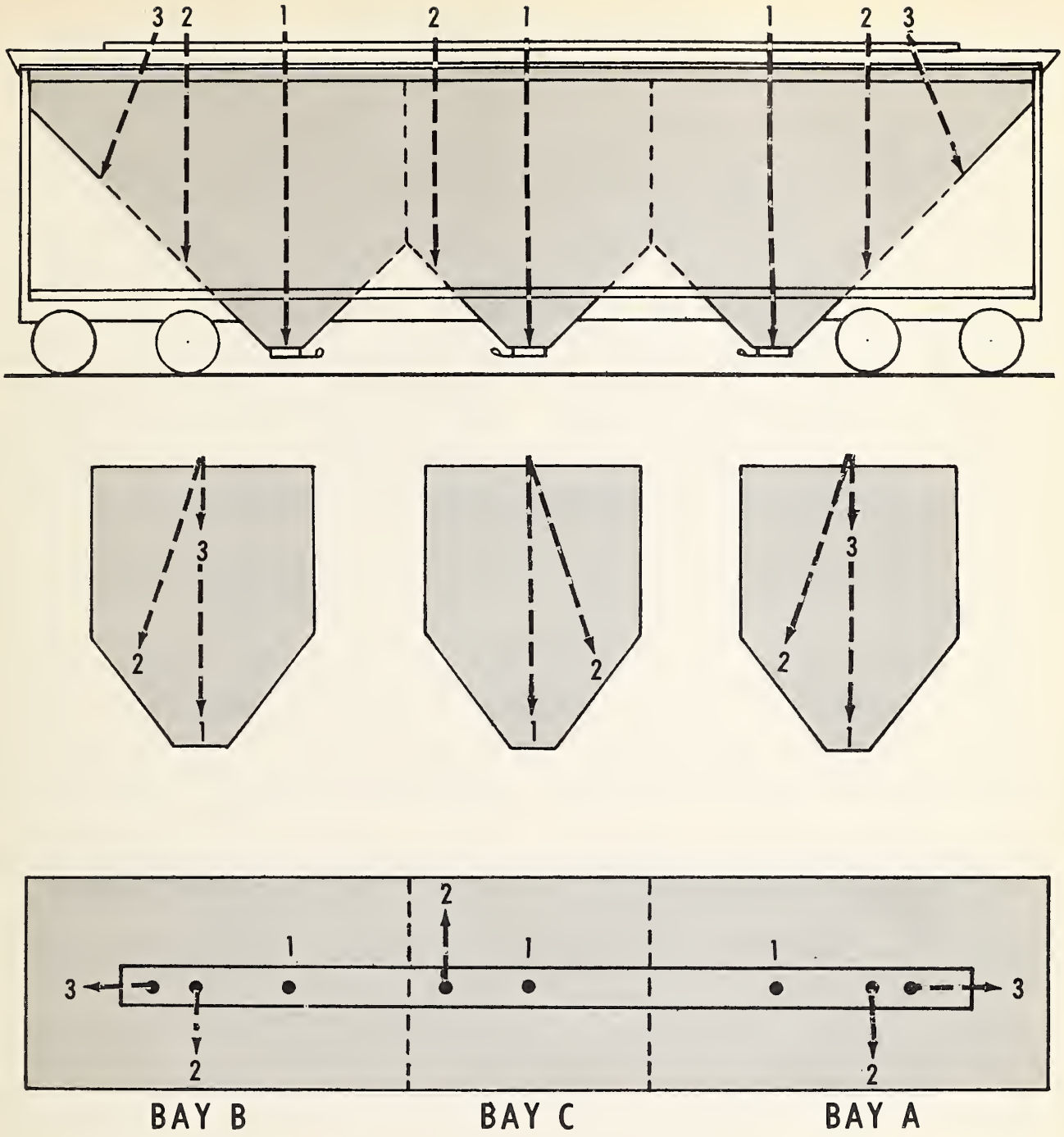

Figure 14.--Probing pattern followed in sampling grain at rest in hopper cars using the 12-foot barge probe, the pneumatic probe, and the Prob-A-Vac.

Lot Separation Into Components After Return To Minneapolis

The wheat, soybean, and corn lots were each separated into their respective components after the sample analyses were completed and all samples had been returned to their lots. The commercial-type sieving equipment used to make these separations was the same equipment used in the initial preparation of the lots.

Sampling of Moving Grain

Minneapolis, out.--The data obtained from the samples drawn from the wheat, soybean, and corn lots during loading into hopper cars at Minneapolis are reported in tables 2 to 4. A summary and the statistical analyses of these data are shown in tables 5 to 7 and graphically in figures 15 to 17.

The data in tables 2 to 4 show that sample weight was reduced by 34 to 49 percent when the diverter slot width was reduced from 0.75 to 0.50 inch. Estimates of the composition of the corn lot were not significantly affected by the reduction in slot width (tables 3 and 6). Percentage of screenings in wheat was overestimated when the slot width was 0.75 inch and the diverter velocity was 100 feet per minute (tables 2 and 5). Percentage of screenings in soybeans was overestimated at both diverter velocities when the slot width was 0.50 inch (tables 4 and 7).

Increasing diverter velocity from 100 to 200 feet per minute decreased sample weight by 47 to 51 percent (tables 2 to 4). Most estimates of lot composition were not significantly affected by changes in diverter velocity (tables 2 to 7).

Significant differences in sample weight were found among the mechanical samplers. Heaviest samples were drawn by the Gustafson sampler; they were nearly double the weight of samples drawn by the other two makes of samplers (tables 2 to 4). Samples drawn by the Strand sampler were usually slightly heavier than samples drawn by the Gamet

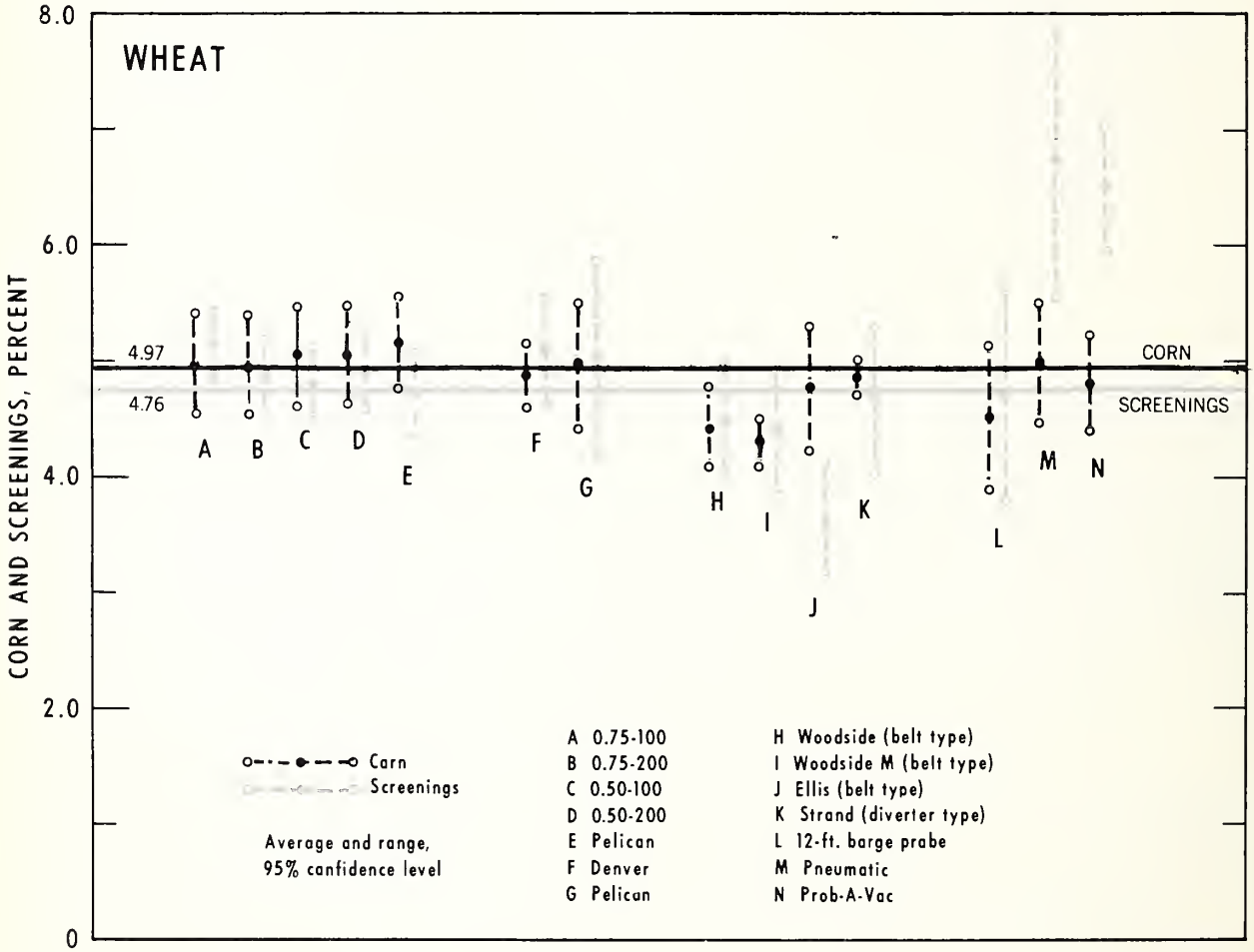

Figure 15.--Percentage of corn and screenings found in wheat lot by samplers.

Table 2.--Weight of components of wheat samples drawn by 4 samplers during loading of hopper car at Minneapolis, percentage of each component in samples, and coefficient of variation, by width of slot opening and diverter velocity of 3 mechanical samplers

Width of slot opening, diverter velocity, and sampler	Grain-flow rate	Weight of composite sample				Components in sample[1]			Coefficient of variation[2]		
		Wheat	Corn	Screenings	Total	Wheat	Corn	Screenings	Wheat	Corn	Screenings
0.75-in. slot											
100 ft./min.:	Lb./min.	Grams	Grams	Grams	Grams	Percent	Percent	Percent	Percent	Percent	Percent
Gamet	2,100	9,142.0	515.4	500.1	10,157.5	90.00	5.07	4.93	9	66	97
Strand	2,087	10,792.0	606.9	620.3	12,019.2	89.79	5.05	5.16	10	79	113
Gustafson	2,113	17,673.0	960.3	1,021.6	19,654.9	89.92	4.88	5.20	9	74	102
Total or average	--	37,607.0	2,082.6	2,142.0	41,831.6	89.90	4.98	*5.12	9	73	104
200 ft./min.:											
Gamet	2,113	4,850.0	287.2	258.0	5,395.2	89.90	5.32	4.78	9	68	102
Strand	2,081	4,791.0	267.6	281.9	5,340.5	89.71	5.01	5.28	11	79	114
Gustafson	2,087	8,670.0	451.3	453.8	9,575.1	90.55	4.71	4.74	11	81	113
Total or average	--	18,311.0	1,006.1	993.7	20,310.8	90.15	4.96	4.89	10	76	110
0.50-in. slot											
100 ft./min.:											
Gamet	2,087	5,683.0	291.2	267.0	6,241.2	91.06	4.66	4.28	9	77	109
Strand	2,100	6,276.0	352.0	369.4	6,997.4	89.69	5.03	5.28	9	60	107
Gustafson	2,081	11,625.5	674.4	619.7	12,919.6	89.98	5.22	4.80	11	80	115
Total or average	--	23,584.5	1,317.6	1,256.1	26,158.2	90.16	5.04	4.80	10	72	110
200 ft./min.:											
Gamet	2,081	3,045.0	171.3	147.3	3,363.6	90.53	5.09	4.38	10	90	109
Strand	2,113	3,010.0	154.9	179.0	3,343.9	90.02	4.63	5.35	10	75	105
Gustafson	2,100	6,220.0	363.0	341.0	6,924.0	89.83	5.24	4.93	9	66	101
Total or average	--	12,275.0	689.2	667.3	13,631.5	90.05	5.05	4.90	10	77	105
Pelican[3]	2,100	9,776.0	515.1	476.7	10,767.8	90.79	4.78	4.43	9	63	108
Pelican[3]	2,081	10,230.0	606.2	562.3	11,398.5	89.75	5.32	4.93	11	86	117
Pelican[3]	2,087	10,180.0	599.3	553.4	11,332.7	89.83	5.29	4.88	10	77	116
Pelican[3]	2,113	9,694.0	558.9	492.0	10,744.9	90.22	5.20	4.58	10	74	108
Total or average	--	39,880.0	2,279.5	2,084.4	44,243.9	90.14	5.15	4.71	10	75	112

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Components of lot: Wheat, 90.27 percent; corn, 4.97 percent; screenings, 4.76 percent.
[2] Calculated from component percentages of approximately 19 increment samples.
[3] Pelican was used for comparison purposes.

Table 3.--Weight of components of corn samples drawn by 4 samplers during loading of hopper car at Minneapolis, percentage of each component in samples and coefficient of variation, by width of slot opening and diverter velocity of 3 mechanical samplers

Width of slot opening, diverter velocity, and sampler	Grain-flow rate	Weight of composite sample			Components in sample[1]		Coefficient of variation[2]	
		Corn	Wheat	Total	Corn	Wheat	Corn	Wheat
0.75-in. slot	Lb./min.	Grams	Grams	Grams	Percent	Percent	Percent	Percent
100 ft./min.:								
Gamet	1,652	7,512.0	379.5	7,891.5	95.19	4.81	5	108
Strand	1,648	9,471.5	455.5	9,927.0	95.41	4.59	3	59
Gustafson	1,623	18,327.1	900.4	19,227.5	95.32	4.68	6	116
Total or average	--	35,310.6	1,735.4	37,046.0	95.31	4.69	5	94
200 ft./min.:								
Gamet	1,623	4,042.9	225.0	4,267.9	94.73	5.27	6	121
Strand	1,652	4,652.7	239.3	4,892.0	95.11	4.89	5	103
Gustafson	1,661	8,202.6	463.0	8,665.6	94.66	5.34	6	116
Total or average	--	16,898.2	927.3	17,825.5	94.80	5.20	6	113
0.50-in. slot								
100 ft./min.:								
Gamet	1,661	3,869.1	217.4	4,086.5	94.68	5.32	6	116
Strand	1,623	5,243.0	289.6	5,532.6	94.77	5.23	6	112
Gustafson	1,648	8,944.4	423.6	9,368.0	95.48	4.52	3	62
Total or average	--	18,056.5	930.6	18,987.1	95.10	4.90	5	97
200 ft./min:								
Gamet	1,648	2,210.6	134.5	2,345.1	94.26	5.74	3	56
Strand	1,661	2,377.5	132.0	2,509.5	94.74	5.26	6	116
Gustafson	1,652	4,604.1	223.1	4,827.2	95.38	4.62	5	106
Total or average	--	9,192.2	489.6	9,681.8	94.79	5.06	5	93
Pelican[3]	1,648	9,256.4	458.6	9,715.0	95.28	4.72	3	58
Pelican[3]	1,661	9,354.1	428.5	9,782.6	95.62	4.38	5	116
Pelican[3]	1,623	10,048.8	513.2	10,562.0	95.14	4.86	6	109
Pelican[3]	1,652	9,685.6	522.6	10,208.2	94.88	5.12	6	110
Total or average	--	38,344.9	1,922.9	40,167.8	95.46	4.54	5	98

[1] Components of lot: Corn, 95.01 percent; wheat, 4.99 percent.
[2] Calculated from component percentages of approximately 24 increment samples.
[3] Pelican was used for comparison purposes.

Table 4.--Weight of components of soybean samples drawn by 4 samplers during loading of hopper car at Minneapolis, percentage of each component in samples, and coefficient of variation, by width of slot opening and diverter velocity of 3 mechanical samplers

Width of slot opening, diverter velocity, and sampler	Grain-flow rate	Weight of composite sample			Components in sample[1]		Coefficient of variation[2]	
		Soybeans	Screenings	Total	Soybeans	Screenings	Soybeans	Screenings
0.75-in. slot	Lb./min.	Grams	Grams	Grams	Percent	Percent	Percent	Percent
100 ft./min.:								
Gamet	1,798	8,491.0	424.2	8,915.2	95.24	4.76	7	140
Strand	1,794	10,880.0	618.8	11,498.8	94.62	5.38	6	122
Gustafson	1,810	17,503.0	913.1	18,416.1	95.04	4.96	6	127
Total or average	--	36,874.0	1,956.1	38,830.1	94.96	5.04	6	130
200 ft./min.:								
Gamet	1,782	4,481.0	228.5	4,709.5	95.15	4.85	6	129
Strand	1,798	4,890.0	279.5	5,169.5	94.59	5.41	7	137
Gustafson	1,794	8,720.0	467.6	9,187.6	94.91	5.09	6	123
Total or average	--	18,091.0	975.6	19,066.6	94.88	5.12	6	130
0.50-in. slot								
100 ft./min.:								
Gamet	1,810	4,681.0	267.9	4,948.9	94.59	5.41	7	131
Strand	1,782	6,160.0	358.1	6,518.1	94.51	5.49	6	119
Gustafson	1,798	8,403.0	534.5	8,937.5	94.02	5.98	8	139
Total or average	--	19,244.0	1,160.5	20,404.5	94.31	*5.69	7	126
200 ft./min.:								
Gamet	1,794	2,703.0	143.5	2,846.5	94.96	5.04	6	126
Strand	1,810	2,800.0	171.4	2,971.4	94.23	5.77	7	125
Gustafson	1,782	4,510.0	287.9	4,797.9	94.00	6.00	8	128
Total or average	--	10,013.0	602.8	10,615.8	94.32	*5.68	7	126
Pelican[3]	1,810	9,623.0	480.7	10,103.7	95.24	4.76	6	126
Pelican[3]	1,782	9,894.0	466.7	10,360.7	95.50	4.50	6	127
Pelican[3]	1,798	10,032.0	466.8	10,498.8	95.55	4.45	6	140
Pelican[3]	1,794	9,710.0	457.5	10,167.5	95.50	4.50	6	129
Total or average	--	39,259.0	1,871.7	41,130.7	95.45	*4.55	7	130

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Components of lot: Soybeans, 95.12 percent; screenings, 4.88 percent.
[2] Calculated from component percentages of approximately 22 increment samples.
[3] Pelican was used for comparison purposes.

Table 5.--Average percentage, deviation, standard deviation, and range of confidence of components of wheat samples drawn by 4 samplers during loading of hopper car at Minneapolis and total and average weight and standard deviation of samples, by width of slot opening and diverter velocity of 3 mechanical samplers

Width of slot opening, diverter velocity, and component	Components in sample[1]	Deviation from lot	Standard deviation	Range of confidence[2]
MECHANICAL SAMPLERS (3)				
0.75-in. slot	Percent	Percent	Percent	Percent
100 ft./min.:				
Wheat	89.90	-.37	--	--
Corn	4.98	.01	.104	4.55-5.41
Screenings	*5.12	.36	.146	4.81-5.43
200 ft./min.:				
Wheat	90.15	.12	--	--
Corn	4.96	.01	.305	4.53-5.39
Screenings	4.89	.13	.301	4.58-5.20
0.50-in. slot				
100 ft./min.:				
Wheat	90.16	-.11	--	--
Corn	5.04	.07	.285	4.61-5.47
Screenings	4.80	.04	.500	4.49-5.11
200 ft./min.:				
Wheat	90.05	-.22	--	--
Corn	5.05	.08	.318	4.62-5.48
Screenings	4.90	.14	.486	4.59-5.21
PELICAN (1)				
Wheat	90.14	-.13	--	--
Corn	5.15	.18	.248	4.75-5.55
Screenings	4.71	.05	.236	4.33-5.09
	Total weight of samples	Average weight of samples	Standard deviation	
0.75-in. slot	Grams	Grams	Grams	
100 ft./min	41,832	13,944	5,033	
200 ft./min	20,311	6,770	2,429	
0.50-in. slot				
100 ft./min	26,158	8,719	3,657	
200 ft./min	13,632	4,544	2,061	
Pelican	44,244	11,061	353	

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Components of lot: Wheat, 90.27 percent; corn, 4.97 percent; screenings, 4.76 percent.
[2] 95-percent confidence level.

Table 6.--Average percentage, deviation, standard deviation and range of confidence of components of corn samples drawn by 4 samplers during loading of hopper car at Minneapolis and total and average weight and standard deviation of samples, by width of slot opening and diverter velocity of 3 mechanical samplers

Width of slot opening, diverter velocity, and component	Components in sample[1]	Deviation from lot	Standard deviation	Range of confidence[2]
MECHANICAL SAMPLERS (3)				
0.75-in slot	Percent	Percent	Percent	Percent
100 ft./min.:				
Corn	95.31	.30	--	--
Wheat	4.69	-.30	.561	4.12-5.26
200 ft./min.:				
Corn	94.80	-.21	--	
Wheat	5.20	.21	.304	4.63-5.77
0.50-in. slot				
100 ft./min.:				
Corn	95.10	.09	--	
Wheat	4.90	-.09	.414	4.33-5.47
200 ft./min.:				
Corn	94.94	-.07	--	
Wheat	5.06	.07	.400	4.49-5.63
PELICAN (1)				
Corn	95.46	.45	--	
Wheat	4.54	-.45	.306	4.05-5.03
	Total weight of samples	Average weight of samples	Standard deviation	
0.75-in. slot	Grams	Grams	Grams	
100 ft./min	37,046	12,349	1,674	
200 ft./min	17,826	5,942	8,534	
0.50-in. slot				
100 ft./min	18,987	6,329	2,971	
200 ft./min	9,682	3,227	2,845	
Pelican	40,168	10,042	396	

[1] Components of lot: Corn, 95.01 percent; wheat, 4.99 percent.
[2] 95-percent confidence level.

Table 7.--Average percentage, deviation, standard deviation, and range of confidence of components of soybean samples drawn by 4 samplers during loading of hopper car at Minneapolis and total and average weight and standard deviation of samples, by width of slot opening and diverter velocity of 3 mechanical samplers

Width of slot opening, diverter velocity, and component	Components in sample[1]	Deviation from lot	Standard deviation	Range of confidence[2]
MECHANICAL SAMPLER (3)				
0.75-in. slot				
100 ft./min.:				
Soybean	94.96	-.16	--	--
Screenings	5.04	.16	.316	4.68-5.40
200 ft./min.:				
Soybean	94.88	-.24	--	--
Screenings	5.12	.24	.281	4.76-5.48
0.50-in. slot				
100 ft./min.:				
Soybean	94.31	-.81	--	
Screenings	*5.69	.81	.320	5.33-6.05
200 ft./min.:				
Soybean	94.32	-.80	--	--
Screenings	*5.68	.80	.360	5.32-6.04
PELICAN (1)				
Soybean	95.45	.33	--	--
Screenings	*4.55	-.33	.137	4.33-4.77
	Total weight of samples	Average weight of samples	Standard deviation	
0.75-in. slot	Grams	Grams	Grams	
100 ft./min	38,830	12,943	4,912	
200 ft./min	19,067	6,356	2,463	
0.50-in. slot				
100 ft./min	20,405	6,802	953	
200 ft./min	10,616	3,539	1,092	
Pelican	41,131	10,283	181	

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Components of lot: Soybeans, 95.12 percent; screenings, 4.88 percent.
[2] 95-percent confidence level.

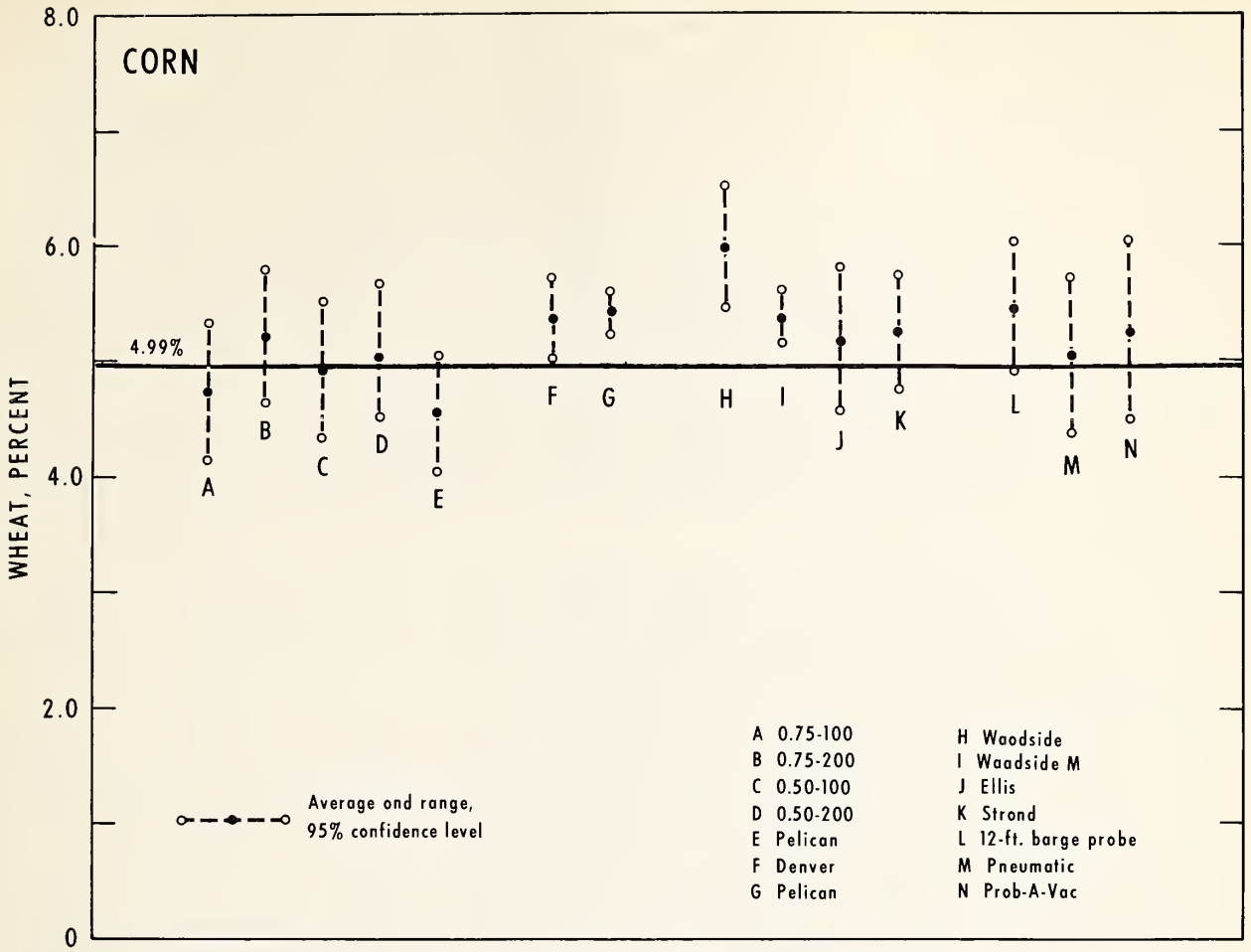

Figure 16.--Percentage of wheat found in corn lot by samplers.

sampler, which is the reverse of the general observation reported in the previous report.[5]

All samplers provided data for estimates of lot composition that seldom exceeded the range of normal random variability. Estimates based on pelican-drawn samples were as good as, but no better than, those based on samples drawn by the diverter-type samplers.

Denver and Omaha.--The wheat, soybean, and corn lots were cycled four times from the hopper cars to a scale garner and back to the hopper cars at Denver and Omaha. During each cycle, the grain was sampled by several types of samplers. The data are reported in tables 8 to 10 and a summary and statistical analyses of the data are given in tables 11 to 13 and are presented graphically in figures 15 to 17.

The weight of samples drawn by the Denver and Strand diverter-type samplers was not appreciably influenced by grain-flow rate. However, when sampling grain flowing at one-half the normal rate, the pelican sampler (at Denver) consistently drew a significantly heavier sample. A probable explanation is that at the higher flow rate, the pelican began to overflow before traversing the entire grain stream. The weight of samples drawn at different flow rates by the three belt-type samplers could not be compared because the flow rate of grain conveyed by belt was not varied.

The deviations of sample percentages from lot percentages (tables 11 to 13) make it possible to compare the performance of the samplers. Table 11 shows that the percentage of corn in the wheat lot was underestimated by about 0.5 percent when the Woodside-type

[5] See footnote 1, page 2.

Table 8.--Weight of components of wheat samples drawn by 6 samplers at Denver and Omaha, percentage of each component, and coefficient of variation for the components

City, sampler, and cycle	Grain-flow rate	Weight of composite sample			Components in sample[1]			Coefficient of variation[2]		
		Wheat	Corn	Screenings	Wheat	Corn	Screenings	Wheat	Corn	Screenings
DENVER										
Denver:	Lb./min.	Grams	Grams	Grams	Percent	Percent	Percent	Percent	Percent	Percent
Cycle 1.....	36,547	47,737.5	2,740.5	2,549.0	90.02	5.17	4.81	1	21	17
Cycle 2.....	17,485	51,645.0	2,829.0	2,945.0	89.94	4.93	5.13	1	19	23
Cycle 3.....	36,239	45,909.0	2,451.5	2,585.0	90.12	4.81	5.07	0	14	16
Cycle 4.....	24,538	49,953.5	2,660.9	3,069.5	89.71	4.78	5.51	1	29	33
Total or average.		195,245.0	10,681.9	11,148.5	89.94	4.92	5.14	1	21	22
Pelican:										
Cycle 1.....	36,547	12,432.0	654.5	798.0	89.54	4.71	5.75	2	13	24
Cycle 2.....	17,485	21,008.5	1,276.5	1,071.0	89.95	5.47	4.58	1	17	20
Cycle 3.....	36,239	12,535.5	662.5	767.5	89.76	4.74	5.50	1	15	17
Cycle 4.....	24,538	19,716.0	1,067.5	1,094.0	90.12	4.88	5.00	1	20	18
Total or average.		65,692.0	3,661.0	3,730.5	89.89	5.01	5.10	1	16	20
OMAHA										
Woodside-type:										
Cycle 1.....	--	12,515.0	598.0	567.0	91.48	4.37	4.15	--	--	--
Cycle 2.....	--	11,836.0	604.5	621.0	90.62	4.63	4.75	--	--	--
Cycle 3.....	--	11,561.0	600.0	581.0	90.73	4.71	4.56	--	--	--
Cycle 4.....	--	11,333.0	526.5	596.5	90.98	4.23	4.79	--	--	--
Total or average.	--	47,245.0	2,329.0	2,365.5	90.96	*4.48	4.56	--	--	--
Woodside-type/(M):[3]										
Cycle 1.....	--	26,430.0	1,299.0	1,174.0	91.44	4.50	4.06	--	--	--
Cycle 2.....	--	25,300.5	1,196.5	1,234.0	91.24	4.31	4.45	--	--	--
Cycle 3.....	--	25,370.0	1,233.5	1,348.5	90.76	4.41	4.83	--	--	--
Cycle 4.....	--	24,777.5	1,139.0	1,235.0	91.26	4.19	4.55	--	--	--
Total or average.	--	101,878.0	4,868.0	4,991.5	91.17	*4.36	4.47	--	--	--
Ellis:										
Cycle 1.....	--	13,256.0	708.9	510.1	91.58	4.90	3.52	2	38	47
Cycle 2.....	--	14,011.0	748.0	586.3	91.30	4.88	3.82	2	33	45
Cycle 3.....	--	13,316.0	626.1	586.0	91.66	4.31	4.03	1	23	39
Cycle 4.....	--	12,383.0	693.1	453.7	91.52	5.12	3.36	2	21	46
Total or average.	--	52,966.0	2,776.1	2,136.1	91.51	4.80	*3.69	2	29	44
Strand:										
Cycle 1 [4].....	25,587	31,559.5	1,677.0	1,859.5	89.92	4.78	5.30	1	9	13
Cycle 2.....	17,885	63,924.5	3,538.5	3,181.5	90.49	5.01	4.50	1	10	15
Cycle 3.....	26,459	64,028.5	3,504.0	3,477.0	90.17	4.93	4.90	1	10	13
Cycle 4.....	18,877	63,809.5	3,447.5	3,133.0	90.65	4.90	4.45	1	10	14
Total or average.	--	223,322.0	12,167.0	11,651.0	90.36	4.92	4.72	1	10	28

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Components of lot: Wheat, 90.27 percent; corn, 4.97 percent; screenings, 4.76 percent.
[2] Calculated from component percentages of approximately 12 increment samples.
[3] Modified model of the Woodside-type sampler.
[4] First half of the sample was lost because of mechanical failure.

Table 9.--Weight of components of corn samples drawn by 6 samplers at Denver and Omaha, percentage of each component, and coefficient of variation for the components

City, sampler, and cycle	Grain-flow rate	Weight of composite sample		Components in sample[1]		Coefficient of variation[2]	
		Corn	Wheat	Corn	Wheat	Corn	Wheat
DENVER	Lb./min.	Grams	Grams	Percent	Percent	Percent	Percent
Denver:							
Cycle 1	33,159	44,926.0	2,401.0	94.93	5.07	1	18
Cycle 2	15,460	44,328.0	2,593.0	94.47	5.53	1	14
Cycle 3	32,858	44,005.0	2,478.5	94.67	5.33	1	13
Cycle 4	15,455	43,745.5	2,563.5	94.46	5.54	1	10
Total or average	--	177,004.5	10,036.0	94.63	*5.37	1	14
Pelican:							
Cycle 1	33,159	15,526.8	884.5	94.61	5.39	1	20
Cycle 2	15,460	31,155.0	1,833.0	94.44	5.56	1	16
Cycle 3	32,858	17,438.5	1,006.5	94.54	5.46	1	10
Cycle 4	15,455	33,514.5	1,863.0	94.73	5.27	1	12
Total or aveaage	--	97,634.8	5,587.0	94.59	*5.41	1	14
OMAHA							
Woodside-type:							
Cycle 1	--	12,158.0	756.0	94.15	5.85	--	--
Cycle 2	--	11,907.5	727.0	94.25	5.75	--	--
Cycle 3	--	12,093.5	837.0	93.53	6.47	--	--
Cycle 4		11,937.0	752.0	94.07	5.93	--	--
Total or average	--	48,096.0	3,072.0	94.00	*6.00	--	--
Woodside-type/(M):[3]							
Cycle 1	--	23,204.5	1,283.0	94.76	5.24	--	--
Cycle 2	--	23,755.0	1,339.0	94.66	5.34	--	--
Cycle 3	--	23,908.0	1,409.0	94.43	5.57	--	--
Cycle 4	--	23,645.5	1,355.0	94.58	5.42	--	--
Total or average	--	94,513.0	5,386.0	94.61	*5.39	--	--
Ellis:							
Cycle 1	--	12,740.3	651.2	95.14	4.86	1	19
Cycle 2	--	12,577.3	630.5	95.23	4.77	1	23
Cycle 3	--	12,436.7	732.1	94.44	5.56	1	24
Cycle 4	--	12,720.2	747.6	94.45	5.55	1	25
Total or average	--	50,474.5	2,761.4	94.81	5.19	1	23
Strand:							
Cycle 1	22,524	61,426.5	3,677.0	94.35	5.65	1	14
Cycle 2	14,162	56,211.0	2,919.5	95.06	4.94	1	15
Cycle 3	22,728	50,929.0	2,826.5	94.74	5.26	1	11
Cycle 4	13,892	55,887.0	3,010.0	94.89	5.11	1	12
Total or average	--	224,453.5	12,433.0	94.75	5.25	11	13

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Components of lot: Corn, 95.01 percent; wheat 4.99 percent.
[2] Calculated from component percentages of approximately 15 increment samples.
[3] Modified model of the Woodside-type sampler.

TABLE 10.--Weight of components of soybean samples drawn by 6 samplers at Denver and Omaha, percentage of each component, and coefficient of variation for the components

City, sampler, and cycle	Grain-flow rate	Weight of composite sample		Components in sample[1]		Coefficient of variation[2]	
		Soybean	Screenings	Soybean	Screenings	Soybean	Screenings
DENVER	Lb./min.	Grams	Grams	Percent	Percent	Percent	Percent
Denver:							
Cycle 1	33,858	46,664.0	3,079.0	93.81	6.19	5	64
Cycle 2	17,374	45,919.0	3,100.0	93.68	6.32	2	36
Cycle 3	32,317	46,753.0	2,701.0	94.54	5.46	2	41
Cycle 4	17,153	47,098.0	2,970.5	94.07	5.93	2	32
Total or average	--	186,434.0	11,850.5	94.02	*5.98	3	43
Pelican:							
Cycle 1	33,858	11,260.0	903.5	92.57	7.43	3	37
Cycle 2	17,374	18,564.0	1,193.3	93.96	6.04	3	47
Cycle 3	32,317	14,922.0	921.6	94.18	5.82	3	50
Cycle 4	17,153	17,783.0	936.0	95.00	5.00	2	30
Total or average	--	62,529.0	3,954.4	94.05	*5.95	3	41
OMAHA							
Woodside-type:							
Cycle 1	--	13,467.5	456.5	96.72	3.28	--	--
Cycle 2	--	13,215.5	535.5	96.11	3.89	--	--
Cycle 3	--	12,068.5	503.0	96.00	4.00	--	--
Cycle 4	--	11,921.0	531.5	95.73	4.27	--	--
Total or average	--	50,672.5	2,026.5	96.15	*3.85	--	--
Woodside-type(M):[3]							
Cycle 1	--	25,631.5	524.0	98.00	2.00	--	--
Cycle 2	--	27,474.5	718.5	97.45	2.55	--	--
Cycle 3	--	25,931.0	929.0	96.54	3.46	--	--
Cycle 4	--	25,531.5	819.5	96.89	3.11	--	--
Total or average	--	104,568.5	2,991.0	97.22	*2.78	--	--
Ellis:							
Cycle 1	--	11,520.5	254.4	97.84	2.16	4	139
Cycle 2	--	11,951.5	378.1	96.93	3.07	4	125
Cycle 3	--	11,740.5	374.6	96.91	3.09	4	145
Cycle 4	--	11,508.0	447.1	96.26	3.74	7	168
Total or average	--	46,720.5	1,454.2	96.98	*3.02	5	144
Strand:							
Cycle 1 [4]	25,880	28,009.0	1,605.5	94.58	5.42	2	39
Cycle 2 [5]	16,026	70,222.5	3,046.0	95.84	4.16	2	44
Cycle 3	26,870	53,968.0	3,170.2	94.45	5.55	2	42
Cycle 4	16,543	59,745.0	2,801.2	95.52	4.48	2	42
Total or average	--	211,944.5	10,622.9	95.23	4.77	2	42

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Components of lot: Soybean, 95.12 percent; screenings, 4.88 percent.
[2] Calculated from component percentages of approximately 14 increment samples.
[3] Modified model of the Woodside-type sampler.
[4] Second half of sample lost because of mechanical failure of the sampler.
[5] Diverter temporarily stuck in grain stream.

Table 11.--Average percentage, deviation, standard deviation, and range of confidence of components of wheat samples drawn by 6 samplers at Denver and Omaha[1]

City and sampler	Components in sample[2]			Deviation from lot percentage			Standard deviation			Range of confidence[3]	
	Wheat	Corn	Screenings	Wheat	Corn	Screenings	Wheat	Corn	Screenings	Corn	Screenings
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
DENVER											
Denver	89.94	4.92	5.14	-0.33	-0.05	0.38	0.173	0.173	0.288	4.64-5.20	4.68-5.60
Pelican	89.89	5.01	5.10	-0.38	0.04	0.34	0.246	0.353	0.521	4.45-5.57	4.27-5.93
OMAHA											
Woodside-type	90.96	*4.48	4.56	0.69	-0.49	-0.20	0.380	0.221	0.291	4.13-4.83	4.10-5.02
Woodside-type(M)[4]	91.17	*4.36	4.47	0.90	-0.61	-0.29	0.289	0.130	0.316	4.15-4.57	3.96-4.98
Ellis	91.51	4.80	*3.69	1.24	-0.17	-1.07	0.151	0.344	0.298	4.25-5.35	3.21-4.17
Strand	90.36	4.92	4.72	0.09	-0.05	-0.04	0.325	0.089	0.396	4.77-5.07	4.09-5.35

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Lot was cycled from pit to leg 4 times.
[2] Components of lot: Wheat, 90.27 percent; corn, 4.97 percent; screenings, 4.76 percent.
[3] 95-percent confidence level.
[4] Modified model of Woodside-type sampler.

Table 12.--Average percentage, deviation, standard deviation, and range of confidence of components of corn samples drawn by 6 samplers at Denver and Omaha[1]

City and sampler	Components in sample[2]		Deviation from lot percentage		Standard deviation		Range of confidence[3]
	Corn	Wheat	Corn	Wheat	Corn	Wheat	Wheat
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
DENVER							
Denver	94.63	*5.37	-0.38	0.38	0.216	0.216	5.02-5.72
Pelican	94.59	*5.41	-0.42	0.42	0.118	0.118	5.22-5.60
OMAHA							
Woodside-type	94.00	*6.00	-1.01	1.01	0.319	0.319	5.49-6.51
Woodside-type(M)[4]	94.61	*5.39	-0.40	0.40	0.134	0.134	5.17-5.61
Ellis	94.81	5.19	-0.20	0.20	0.427	0.427	4.58-5.80
Strand	94.75	5.25	-0.26	0.26	0.301	0.301	4.77-5.73

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Lot was cycled from pit to leg 4 times.
[2] Components of lot: Corn, 95.01 percent; wheat, 4.99 percent.
[3] 95-percent confidence level.
[4] Modified model of Woodside-type sampler.

Table 13.--Average percentage, deviation, standard deviation, and range of confidence of components of soybean samples drawn by 6 samplers at Denver and Omaha[1]

City and sampler	Components in sample[2]		Deviation from lot percentage		Standard deviation		Range of confidence[3]
	Soybeans	Screenings	Soybean	Screenings	Soybean	Screenings	Screenings
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
DENVER							
Denver	94.02	*5.98	-1.10	1.10	.378	.378	5.38-6.58
Pelican	94.05	*5.95	-1.07	1.07	1.008	1.008	5.45-6.45
OMAHA							
Woodside-type	96.15	*3.85	1.03	-1.03	.417	.417	3.18-4.52
Woodside-type(M)[4]	97.22	*2.78	2.10	-2.10	.319	.319	1.76-3.80
Ellis	96.98	*3.02	1.86	-1.86	.648	.648	1.99-4.05
Strand	95.23	4.77	.11	-0.11	.686	.686	3.68-5.86

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Lot was cycled from pit to leg 4 times.
[2] Components of lot: Soybean, 95.12 percent; screenings, 4.88 percent.
[3] 95-percent confidence level.
[4] Modified model of Woodside-type sampler.

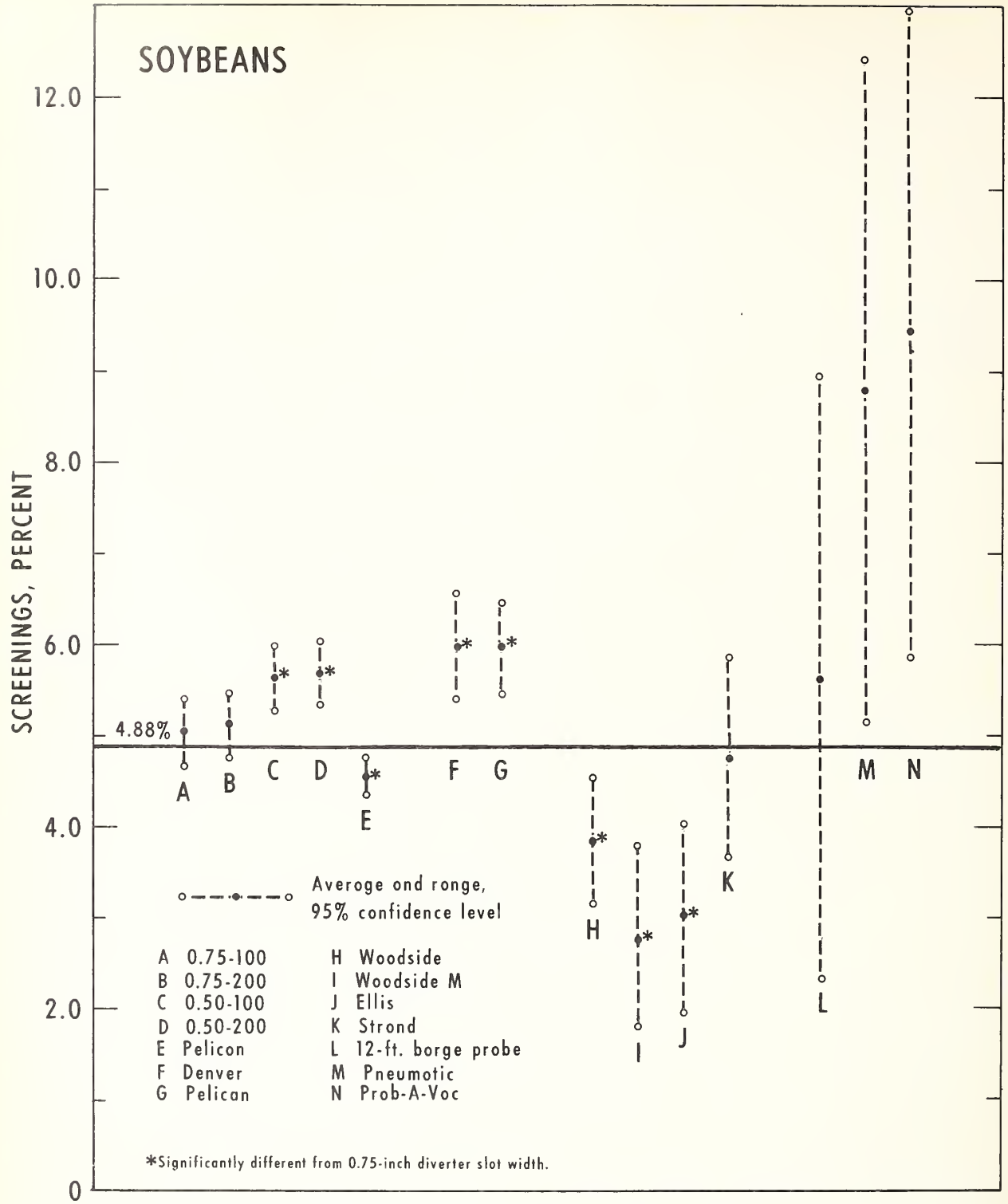

Figure 17.--Percentage of screenings found in soybean lot by samplers.

and Woodside-type modified samplers were used. When the Ellis sampler was used the estimate of the percentage of screenings in the wheat lot was too low. The percentage of wheat in the corn lot was overestimated when all samplers were used (table 12). When all samplers were used, the percentage of screenings in soybeans was incorrectly estimated except the percentage based on samples taken by the Strand (table 13).

Minneapolis, in.--Tables 14 to 16 show the data for samples of wheat, soybeans, and corn drawn by the Gamet, Strand, Gustafson, and pelican samplers during unloading at Minneapolis. Tables 17 to 19 and figures 15 to 17 give a summary of the data.

The weight of samples drawn during unloading at Minneapolis agreed with the sample weight during loading of the hopper cars at Minneapolis. Reducing the diverter slot width from 0.75 to 0.50 inch and increasing diverter velocity from 100 to 200 feet per minute reduced sample weight.

Coefficients of variation (tables 2 to 4, 8 to 10, and 14 to 16) show that the homogeneity of the lots generally increased with progressive handling of the grains. A lower coefficient of variation indicates that a lot is more homogeneous. Screenings in soybeans consistently had the highest coefficient of variation.

The three diverter-type samplers performed well, as shown by the data in tables 17 to 19. Deviations from known lot percentages were generally quite small; the largest deviations were for screenings in soybeans.

Sampling of Grain at Rest in Covered Hopper Cars

Performance of three types of probe samplers.--The wheat, soybean, and corn lots, transported in the three covered hopper cars, were each sampled after loading and before unloading using three types of probe samplers (12-foot barge, pneumatic, and Prob-A-Vac). The data for the samples (drawn by vertical probing) are included in tables 20 to 22, and summaries of these data and the statistical analyses are presented in tables 23 to 25. The data are also shown graphically in figures 15 to 17.

The Prob-A-Vac consistently drew the heaviest sample. The barge probe drew a sample approximately one-fifth the weight of the sample drawn by the pneumatic, which in turn was about one-half the weight of the sample drawn by the Prob-A-Vac.

Samples drawn by the probes provided a good estimate of wheat in the corn lot and of corn in the wheat lot. But estimates of screenings in the wheat and soybean lots were inaccurate. The reason for this inaccuracy poses the question: Were the probes themselves inaccurate, or was the probing pattern at fault? The same probing pattern was used for each device during each probing (fig. 14). The component percentages reported in tables 20 to 22 were arranged in the following pairs: Minneapolis out--Denver in; Denver out--Omaha in; and Omaha out--Minneapolis in. Tables 26 to 28 show the lot component percentages did not change significantly between pairs of samplings by each device. The correlation between pairs was found to be 0.99 for the barge, 0.98 for the pneumatic, and 0.97 for the Prob-A-Vac.

Tables 2 to 4, 8 to 10, and 14 to 16 show that the components were unevenly distributed in the corn, wheat, and soybean lots. No doubt this distribution was quite different each time the lots were loaded into the hopper cars. The possibility of specifying an adequate, yet practical, probing pattern for nonhomogeneous grain loaded into hopper cars seems remote.

Effect of transport in a hopper car on relocation of lot components.--Tables 26 to 28 give the percentages of components found in the samples drawn by three types of probes (12-foot barge, pneumatic, and Prob-A-Vac) from the lower and upper layers of grain after each loading and before each unloading. A statistical analysis of these data show there was no significant relocation of the components in the wheat, soybean, and corn lots during transportation between elevators.

Vertical probing versus vertical-plus-slant probing.--Two sampling patterns were used in sampling with the 12-foot barge probe: (1) Vertically at deepest part of each bay and (2) vertically at deepest part of each bay plus slanting toward each end and slanting toward side of each bay (fig. 14). The data for the samples drawn by the two probing patterns are shown in tables 29 to 31.

Table 14.--Weight and coefficient of variation of components of wheat samples drawn by 4 samplers during unloading of hopper car at Minneapolis, by width of slot opening and diverter velocity of 3 mechanical samplers

Sampler, width of slot opening, diverter velocity, and bin	Grain-flow rate	Weight of composite sample				Coefficient of variation[1]		
		Wheat	Corn	Screenings	Total	Wheat	Corn	Screenings
	Lb./min.	Grams	Grams	Grams	Grams	Percent	Percent	Percent
Gamet, 0.50-in. slot, 200 ft./min.:								
Bin A	2,078	2,956.5	160.0	142.8	3,259.3	1	26	23
Bin B	2,037	2,887.0	167.7	162.3	3,217.0	2	43	51
Bin C	2,027	2,915.0	148.4	161.0	3,244.4	2	33	44
Bin D	2,116	2,806.5	154.4	161.5	3,122.4	2	37	44
Total or average	--	11,565.0	630.5	627.6	12,823.1	2	35	40
Strand, 0.75-in. slot, 100 ft./min:								
Bin A	2,078	10,317.0	554.0	490.0	11,361.0	1	26	32
Bin B	2,037	10,824.5	628.1	540.1	11,992.7	2	25	43
Bin C	2,027	10,663.0	541.9	555.9	11,760.8	1	20	29
Bin D	2,116	9,735.5	525.5	591.0	10,852.0	2	35	40
Total or average	--	41,540.0	2,249.5	2,177.0	45,966.5	2	26	36
Gustafson, 0.50-in. slot, 100 ft./min:								
Bin A	2,078	9,790.5	554.6	524.5	10,869.6	2	29	37
Bin B	2,037	10,068.0	650.2	482.8	11,201.0	2	40	38
Bin C	2,027	9,611.0	550.6	526.4	10,688.0	1	23	29
Bin D	2,116	9,315.0	520.9	559.0	10,394.9	1	29	37
Total or average	--	38,784.5	2,276.3	2,092.7	43,153.5	2	30	35
Pelican:								
Bin A	2,078	6,314.5	373.7	278.8	6,967.0	2	34	26
Bin B	2,037	6,244.0	359.7	291.7	6,895.4	2	32	37
Bin C	2,027	8,337.0	437.6	424.3	9,198.9	1	22	25
Bin D	2,116	7,160.0	376.9	369.4	7,906.3	1	26	35
Total or average	--	28,055.5	1,547.9	1,364.2	30,967.6	2	28	31

[1] Calculated from component percentages of approximately 19 increment sample.

Table 15.--Weight and coefficient of variation of components of corn samples drawn by 4 samplers during unloading of hopper car at Minneapolis, by width of slot opening and diverter velocity of 3 mechanical samplers

Sampler, width of slot opening, diverter velocity, and bin	Grain-flow rate	Weight of composite sample			Coefficient of variation[1]	
		Corn	Wheat	Total	Corn	Wheat
	Lb./min.	Grams	Grams	Grams	Percent	Percent
Gamet, 0.50-in. slot, 100 ft./min:						
Bin A	1,586	3,667.6	232.5	3,900.1	1	16
Bin B	1,715	3,686.7	200.1	3,886.8	1	22
Bin C	1,624	3,602.3	198.9	3,801.2	1	21
Bin D	1,659	3,289.4	187.0	3,476.4	1	19
Total or average	--	14,246.0	818.5	15,064.5	1	20
Strand, 0.50-in. slot, 200 ft./min.:						
Bin A	1,586	2,561.9	162.1	2,724.0	1	19
Bin B	1,715	2,339.9	133.2	2,473.1	1	16
Bin C	1,624	2,463.3	140.0	2,603.3	1	20
Bin D	1,659	2,176.5	116.3	2,292.8	1	27
Total or average	--	9,541.6	551.6	10,093.2	1	20
Gustafson, 0.75-in. slot, 100 ft./min.:						
Bin A	1,586	16,905.4	1,003.0	17,908.4	1	17
Bin B	1,715	16,695.9	863.4	17,559.3	1	20
Bin C	1,624	17,146.2	877.5	18,023.7	1	17
Bin D	1,659	15,138.5	733.7	15,872.2	1	23
Total or average	--	65,886.0	3,477.6	69,363.6	1	19
Pelican:						
Bin A	1,586	6,162.8	369.0	6,531.8	1	19
Bin B	1,715	6,428.8	320.4	6,749.2	1	15
Bin C	1,624	6,696.5	348.5	7,045.0	1	12
Bin D	1,659	6,909.8	327.9	7,237.7	1	17
Total or average	--	26,197.9	1,365.8	27,563.7	1	16

[1] Calculated from component percentages of approximately 24 increment samples.

Table 16.--Weight and coefficient of variation of components of soybean samples drawn by 4 samplers during unloading of hopper car at Minneapolis, by width of slot opening and diverter velocity of mechanical samplers

Sampler, width of slot opening, diverter velocity, and bin	Grain-flow rate	Weight of composite sample			Coefficient of variation[1]	
		Soybean	Screenings	Total	Soybean	Screenings
	Lb./min.	Grams	Grams	Grams	Percent	Percent
Gamet, 0.75-in. slot, 100 ft./min.:						
Bin A	1,791	8,262.0	530.3	8,792.3	5	80
Bin B	1,744	8,257.0	374.7	8,631.7	4	95
Bin C	1,924	8,102.0	503.6	8,605.6	5	83
Bin D	1,780	7,636.0	323.9	7,959.9	4	104
Total or average	--	32,257.0	1,732.5	33,989.5	4	90
Strand, 0.50-in. slot, 100 ft./min.:						
Bin A	1,791	6,424.5	424.4	6,848.9	5	78
Bin B	1,744	6,331.0	288.0	6,619.0	4	100
Bin C	1,924	6,127.5	382.3	6,509.8	5	80
Bin D	1,780	5,426.0	254.2	5,680.2	6	130
Total or average	--	24,309.0	1,348.9	25,657.9	5	97
Gustafson, 0.50-in. slot, 200 ft./min.:						
Bin A	1,791	4,379.0	332.7	4,711.7	5	64
Bin B	1,744	4,464.0	210.5	4,674.5	4	82
Bin C	1,924	4,355.0	281.9	4,636.9	5	74
Bin D	1,780	4,267.0	200.6	4,467.6	4	92
Total or average	--	17,465.0	1,025.7	18,490.7	4	78
Pelican:						
Bin A	1,791	9,777.0	555.3	10,332.3	4	63
Bin B	1,744	10,545.5	358.9	10,904.4	3	83
Bin C	1,924	10,479.0	537.1	11,016.1	4	78
Bin D	1,780	10,413.0	356.3	10,769.3	3	88
Total or average	--	41,214.5	1,807.6	43,022.1	4	78

[1] Calculated from component percentages of approximately 22 increment samples.

Table 17.--Average percentage and deviation of components of wheat samples drawn by 4 samplers during unloading of hopper car at Minneapolis and total and average weight and standard deviation of samples, by width of slot opening and diverter velocity of 3 mechanical samplers

Sampler, width of slot opening, and diverter velocity	Components in sample[1]			Deviation from lot percentage			Weight of sample		
	Wheat	Corn	Screenings	Wheat	Corn	Screenings	Total	Average	Standard deviation
	Percent	Percent	Percent	Percent	Percent	Percent	Grams	Grams	Grams
Gamet, 0.50-in. slot, 200 ft./min.	90.19	4.92	4.89	-.08	-.05	+.13	12,823	3,206	59
Strand, 0.75-in. slot 100 ft./min.	90.37	4.89	4.74	.10	-.08	-.02	45,967	11,492	500
Gustafson, 0.50-in. slot, 100 ft./min.	89.88	5.27	4.85	-.39	.30	.09	43,154	10,788	388
Pelican	90.60	5.00	4.40	.33	.03	-.36	30,968	7,742	1,075

[1] Components of lots: Wheat, 90.27 percent; corn, 4.97 percent; screenings, 4.76 percent.

Table 18.--Average percentage and deviation of components of corn samples drawn by 4 samplers during unloading of hopper car at Minneapolis, and total and average weight and standard deviation of samples, by width of slot opening and diverter velocity of 3 mechanical samplers

Sampler, width of slot opening, and diverter velocity	Components in sample[1]		Deviation from lot percentage		Weight of sample		
	Corn	Wheat	Corn	Wheat	Total	Average	Standard deviation
	Percent	Percent	Percent	Percent	Grams	Grams	Grams
Gamet, 0.50-in. slot, 100 ft./min.	94.57	5.43	-.44	.44	15,065	3.766	198
Strand, 0.50-in. slot, 200 ft./min.	94.53	5.47	-.48	.48	10,093	2,523	185
Gustafson, 0.75-in. slot, 100 ft./min.	94.99	5.01	-.02	-.02	69,364	17,341	999
Pelican	95.04	4.96	.03	-.03	27,564	6,891	313

[1] Components of lot: Corn, 95.01 percent; wheat, 4.99 percent.

Table 19.--Average percentage and deviation of components of soybean samples drawn by 4 samplers during unloading of hopper car at Minneapolis, and total and average weight and standard deviation of samples, by width of slot opening and diverter velocity of 3 mechanical samplers

Sampler, width of slot opening, and diverter velocity	Components in sample[1]		Deviation from lot percentage		Weight of sample		
	Soybeans	Screenings	Soybeans	Screenings	Total	Average	Standard deviation
	Percent	Percent	Percent	Percent	Grams	Grams	Grams
Gamet, 0.75-in. slot, 100 ft./min.	94.90	5 10	-.22	.22	33,990	8,497	368
Strand, 0.50-in. slot, 100 ft./min.	94.74	5.26	-.38	.38	25,658	6,415	510
Gustafson, 0.50-in. slot, 200 ft./min.	94.45	5.55	-.67	.67	18,491	4,623	108
Pelican	95.80	4.20	.68	-.68	43,022	10,756	300

[1] Components of lot: Soybean, 95.12 percent; screenings, 4.88 percent.

Table 20.--Weight of components of wheat samples drawn by 3 types of probes from hopper car after loading and before unloading at Minneapolis, Denver, and Omaha, and percentage of each component in samples, by type of probe and city

Sampler, city, and sampling frequency[1]	Weight and sample				Components in sample[2]		
	Wheat	Corn	Screenings	Total	Wheat	Corn	Screenings
	Grams	Grams	Grams	Grams	Percent	Percent	Percent
BARGE							
Minneapolis, out	2,478.0	138.4	184.2	2,800.6	88.48	4.94	6.58
Denver, in	2,126.5	133.4	173.2	2,433.1	87.40	5.48	7.12
Denver, out	2,332.0	101.4	128.4	2,561.8	91.03	3.96	5.01
Omaha, in	2,120.5	96.1	130.2	2,346.8	90.36	4.09	5.55
Omaha, out	2,350.5	106.8	132.9	2,590.2	90.75	4.12	5.13
Minneapolis, in	2,144.0	112.5	123.9	2,380.4	90.70	4.73	5.20
Total or average[3]	13,551.5	688.6	872.8	15,112.9	89.67	4.56	5.77
PNEUMATIC							
Minneapolis, out	13,506.0	860.2	1,371.9	15,738.1	85.82	5.46	8.72
Denver, in	10,526.5	690.0	773.2	11,989.7	87.80	5.75	6.45
Denver, out	8,673.0	453.5	562.0	9,688.5	89.52	4.68	5.80
Omaha, in	9,393.0	478.5	612.0	10,483.5	89.60	4.56	5.84
Omaha, out	8,570.5	474.0	583.0	9,627.5	89.02	4.92	6.06
Minneapolis, in	10,010.0	510.0	740.0	11,260.0	88.90	4.53	6.57
Total or average[3]	60,679.0	3,466.2	4,642.1	68,787.3	88.21	5.04	*6.75
PROB-A-VAC							
Minneapolis, out	21,478.0	1,163.0	1,507.8	24,148.8	88.94	4.82	6.24
Denver, in	17,077.0	1,108.0	1,457.6	19,642.6	86.94	5.64	7.42
Denver, out	14,207.0	743.0	950.0	15,900.0	89.35	4.67	5.98
Omaha, in	15,197.0	815.0	1,051.5	17,063.5	89.06	4.78	6.16
Omaha, out	14,454.0	738.5	1,093.0	16,285.5	88.76	4.53	6.71
Minneapolis, in	15,250.0	796.5	1,129.0	17,175.5	88.79	4.64	6.57
Total or average[3]	97,663.0	5,364.0	7,188.9	110.215.9	88.61	4.87	*6.52

*Significantly different at the 95-percent confidence level from the lot mean.

[1] Out: Samples were drawn from loaded car before it was moved out of city named. In: Samples were drawn before car was unloaded after arrival from another city.

[2] Components of lot: Wheat, 90.27 percent; corn, 4.97 percent; screenings, 4.76.

[3] Average based on total weights.

Table 21.--Weight of components of corn samples drawn by 3 types of probes from hopper car after loading and before unloading at Minneapolis, Denver, and Omaha, and percentage of each component in samples, by type of probe and city

Sampler, city and sampling frequency[1]	Weight of sample			Components in sample[2]	
	Corn	Wheat	Total	Corn	Wheat
	Grams	Grams	Grams	Percent	Percent
BARGE					
Minneapolis, out	2,284.1	125.0	2,409.1	94.81	5.19
Denver, in	2,050.3	99.7	2,150.0	95.36	4.64
Denver, out	2,035.1	121.4	2,156.5	94.37	5.63
Omaha, in	1,957.5	110.9	2,068.4	94.64	5.36
Omaha, out	1,932.4	123.4	2,055.8	94.00	6.00
Minneapolis, in	2,020.5	130.3	2,150.8	93.94	6.06
Total or average[3]	12,279.9	710.7	12,990.6	94.53	5.47
PNEUMATIC					
Minneapolis, out	10,507.9	475.3	10,983.2	95.67	4.33
Denver, in	10,387.5	478.4	10,865.9	95.60	4.40
Denver, out	8,137.5	440.0	8,577.5	94.87	5.13
Omaha, in	9,229.5	499.5	9,729.0	94.87	5.13
Omaha, out	8,634.5	550.5	9,185.0	94.01	5.99
Minneapolis, in	9,421.5	551.0	9,972.5	94.47	5.53
Total or average[3]	56,318.4	2,994.7	59,313.1	94.95	5.05
PROB-A-VAC					
Minneapolis, out	19,121.5	955.4	20,076.9	95.24	4.76
Denver, in	17,523.8	841.1	18,364.9	95.42	4.58
Denver, out	13,393.0	770.5	14,163.5	94.56	5.44
Omaha, in	13,910.5	779.5	14,690.0	94.69	5.31
Omaha, out	11,742.0	758.5	12,500.5	93.93	6.07
Minneapolis, in	14,223.0	887.0	15,110.0	94.13	5.87
Total or average[3]	89,913.8	4,992.0	94,905.8	94.74	5.26

[1] Out: Samples were drawn from loaded car before it was moved out of city named. In: Samples were drawn before car was unloaded after arrival from another city.

[2] Components of lot: Corn, 95.01 percent; wheat, 4.99 percent.

[3] Averages based on total weights.

Table 22.--Weight of components of soybean samples drawn by 3 types of probes from hopper car after loading and before unloading at Minneapolis, Denver, and Omaha, and percentage of each component in samples, by type of probe and city

Sampler, city and sampling frequency[1]	Weight of sample			Components in sample[2]	
	Soybeans	Screenings	Total	Soybeans	Screenings
	Grams	Grams	Grams	Percent	Percent
BARGE					
Minneapolis, out	2,231.0	242.9	2,473.9	90.18	9.82
Denver, in	2,049.0	201.4	2,250.4	91.05	8.95
Denver, out	2,186.0	65.9	2,251.9	97.07	2.93
Omaha, in	1,973.0	45.1	2,018.1	97.77	2.23
Omaha, out	2,073.5	100.8	2,174.3	95.36	4.64
Minneapolis, in	2,013.0	90.5	2,103.5	95.70	4.30
Total or average[3]	12,525.5	746.6	13,272.1	94.37	5.63
PNEUMATIC					
Minneapolis, out	8,640.0	1,266.9	9,906.9	87.21	12.79
Denver, in	10,131.0	1,535.0	11,666.0	86.84	13.16
Denver, out	10,326.0	594.3	10,920.3	94.56	5.44
Omaha, in	9,991.0	556.5	10,547.5	94.72	5.28
Omaha, out	8,173.5	671.3	8,844.8	92.41	7.59
Minneapolis, in	10,099.0	902.3	11,001.3	91.80	8.20
Total or average[3]	57,360.5	5,526.3	62,886.8	91.21	*8.79
PROB-A-VAC					
Minneapolis, out	16,286.0	2,621.3	18,907.3	86.14	13.86
Denver, in	17,395.0	2,599.0	19,994.0	87.00	13.00
Denver, out	16,262.0	1,045.8	17,307.8	93.96	6.04
Omaha, in	16,899.5	1,096.5	17,996.0	93.91	6.09
Omaha, out	15,251.0	1,388.9	16,639.9	91.65	8.35
Minneapolis, in	16,949.0	1,555.9	18,504.9	91.59	8.41
Total or average[3]	99,042.5	10,307.4	109,349.9	90.57	*9.43

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Out: Samples were drawn from loaded car before it was moved out of city named. In: Samples were drawn before car was unloaded after arrival from another city.
[2] Components of lot: Soybean, 95.12 percent; screenings, 4.88 percent.
[3] Averages based on total weights.

Table 23.--Average percentage,[1] deviation, standard deviation, and range of confidence of components of wheat samples drawn from hopper car, and total and average weight and standard deviation of samples, by type of probe used

Component and type of probe	Components in sample[2]	Deviation from lot	Standard deviation	Range of confidence[3]
	Percent	Percent	Percent	Percent
WHEAT				
Barge	89.67	-.60	1.43	--
Pneumatic	88.21	-2.06	1.44	--
Prob-A-Vac	88.61	-1.66	.86	--
CORN				
Barge	4.56	-.41	.60	3.93-5.19
Pneumatic	5.04	.07	.51	4.51-5.57
Prob-A-Vac	4.87	-.10	.40	4.45-5.29
SCREENINGS				
Barge	5.77	1.10	.88	3.85-5.69
Pneumatic	*6.75	1.99	1.10	5.60-7.90
Prob-A-Vac	*6.52	1.76	.52	5.98-7.06
	Total weight of sample	Average weight of sample	Standard deviation	
	Grams	Grams	Grams	
ALL COMPONENTS				
Barge	15,113	2,519	169	--
Pneumatic	68,787	11,465	2,284	--
Prob-A-Vac	110,216	18,370	3,118	--

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Weighted average for 6 samples.
[2] Component of lot: Wheat, 90.27 percent; corn, 4.97 percent; screenings, 4.76 percent.
[3] 95-percent confidence level.

Table 24.--Average percentage,[1] deviation, standard deviation, and range of confidence of components of corn samples drawn from hopper car, and total and average weight and standard deviation of samples, by type of probe used

Component and type of probe	Components in sample[2]	Deviation from lot	Standard deviation	Range of confidence[3]
	Percent	Percent	Percent	Percent
CORN				
Barge	94.53	-.48	0.53	--
Pneumatic	94.95	-.06	0.64	--
Prob-A-Vac	94.74	-.25	0.59	--
WHEAT				
Barge	5.47	.48	0.53	4.91-6.03
Pneumatic	5.05	.06	0.64	4.38-5.72
Prob-A-Vac	5.26	.25	0.59	4.50-6.02
	Total weight of sample	Average weight of sample	Standard deviation	
	Grams	Grams	Grams	
ALL COMPONENTS				
Barge	12,991	2,165	128	--
Pneumatic	59,313	9,886	938	--
Prob-A-Vac	94,906	15,818	2,833	--

[1] Weighted average for 6 samples.
[2] Component of lot: Corn, 95.01 percent; wheat, 4.99 percent.
[3] 95-percent confidence level.

Table 25.--Average percentage,[1] deviation, standard deviation, and range of confidence of components of soybean samples drawn from hopper car, and total and average weight and standard deviation of samples, by type of probe used

Component and type of probe	Components in sample[2]	Deviation from lot	Standard deviation	Range of confidence[3]
	Percent	Percent	Percent	Percent
SOYBEAN				
Barge	94.37	-.75	3.16	--
Pneumatic	91.21	-3.91	3.48	--
Prob-A-Vac	90.57	-4.55	3.38	--
SCREENINGS				
Barge	5.63	.75	3.16	2.31-8.95
Pneumatic	*8.79	3.91	3.48	5.14-12.44
Prob-A-Vac	*9.43	4.55	3.38	5.88-12.98
	Total weight of sample	Average weight of sample	Standard deviation	
	Grams	Grams	Grams	
ALL COMPONENTS				
Barge	13,272	2,212	156	--
Pneumatic	62,887	10,481	988	--
Prob-A-Vac	109,350	18,225	1,190	--

*Significantly different at the 95-percent confidence level from the lot mean.
[1] Weighted average for 6 samples.
[2] Components of lot: Soybean 95.12 percent; screenings, 4.88 percent.
[3] 95-percent confidence level.

Table 26.--Percentages of corn and screenings in wheat samples drawn from the top and bottom layers in the hopper car after loading and before unloading at Minneapolis, Denver, and Omaha, by city, sampling sequence, and bay

[Data are averages of component weights drawn by 3 different probes]

City, sampling sequence, and bay[1]	Components in sample[2]			
	Top layer[3]		Bottom layer[3]	
	Corn	Screenings	Corn	Screenings
	Percent	Percent	Percent	Percent
MINNEAPOLIS-OUT				
Bay B	5.28	9.21	1.93	.74
Bay C	5.24	6.66	5.34	4.58
Bay A	5.36	8.65	6.94	13.75
Average[4]	5.28	7.85	4.81	6.39
DENVER-IN				
Bay B	5.68	9.10	2.05	0.78
Bay C	6.72	8.54	6.63	5.09
Bay A	4.99	5.96	8.06	13.41
Average[4]	5.87	8.03	5.51	6.27
DENVER-OUT				
Bay B	4.87	5.69	4.42	4.67
Bay C	5.39	5.58	4.94	5.45
Bay A	4.30	5.91	3.99	7.86
Average[4]	4.79	5.75	4.47	5.89
OMAHA-IN				
Bay B	4.61	5.84	4.55	4.54
Bay C	5.96	6.37	4.43	5.42
Bay A	4.15	6.42	4.59	7.36
Average[4]	4.82	6.26	4.51	5.79
OMAHA-OUT				
Bay B	4.97	5.41	4.76	6.38
Bay C	4.52	5.62	4.34	6.71
Bay A	4.39	7.40	4.82	6.51
Average[4]	4.63	6.12	4.63	6.54
MINNEAPOLIS-IN				
Bay B	4.73	5.80	5.06	5.07
Bay C	4.51	5.80	4.05	7.47
Bay A	4.45	7.39	4.76	6.39
Average[4]	4.56	6.28	4.64	6.62

[1] Out: Samples were drawn from loaded car before it was moved out of city named. In: Samples were drawn before car was unloaded after arrival from another city. B, refers to brake end bay; C, center bay; A, alternate end (opposite brake end).
[2] Components of lot: Wheat, 90.27 percent; corn, 4.97 percent; screenings, 4.76 percent.
[3] All samples in this table were drawn vertically at deepest part of bay. Top layer: Samples drawn between point 5 feet above bottom of bay and surface of grain. Bottom layer: Samples drawn between bottom of bay and point 5 feet above bottom.
[4] Average based on total weights.

Table 27.--Percentages of corn and wheat in corn samples drawn from the top and bottom layers in the hopper car after loading and before unloading at Minneapolis, Denver, and Omaha, by city, sampling sequence, and bay

[Data are averages of component weights drawn by 3 different probes]

City, sampling sequence, and bay[1]	Components in sample[2]			
	Top layer[3]		Bottom layer[3]	
	Corn	Wheat	Corn	Wheat
	Percent	Percent	Percent	Percent
MINNEAPOLIS-OUT				
Bay B.....	94.83	5.17	99.66	.34
Bay C.....	93.12	6.88	96.20	3.80
Bay A.....	93.07	6.93	96.21	3.79
Average[4].....	93.68	6.32	97.42	2.58
DENVER-IN				
Bay B.....	94.30	5.70	99.75	.25
Bay C.....	93.02	6.98	96.11	3.89
Bay A.....	93.31	6.69	96.46	3.54
Average[4].....	93.54	6.46	97.35	2.65
DENVER-OUT				
Bay B.....	94.45	5.55	95.43	4.57
Bay C.....	94.93	5.07	95.12	4.88
Bay A.....	93.35	6.65	94.23	5.77
Average[4].....	94.27	5.73	95.00	5.00
OMAHA-IN				
Bay B.....	95.58	5.42	95.52	4.48
Bay C.....	94.85	5.15	95.24	4.76
Bay A.....	93.55	6.45	94.54	5.46
Average[4].....	94.35	5.65	95.12	4.88
OMAHA-OUT				
Bay B.....	93.78	6.22	93.01	6.99
Bay C.....	94.60	5.40	94.50	5.50
Bay A.....	94.63	5.37	93.20	6.80
Average[4].....	94.35	5.65	93.55	6.45
MINNEAPOLIS-IN				
Bay B.....	94.56	5.44	94.84	5.16
Bay C.....	94.79	5.21	93.86	6.14
Bay A.....	93.72	6.28	93.45	6.55
Average[4].....	94.42	5.58	94.06	5.94

[1] Out: Samples were drawn from loaded car before it was moved out of city named. In: Samples were drawn before car was unloaded after arrival from another city. B, refers to brake end bay; C, center bay; A, "alternate end" (Opposite brake end).

[2] Components of lot: Corn, 95.01 percent: wheat, 4.99 percent.

[3] All samples in this table were drawn vertically at deepest part of bay. Top layer: Samples drawn between point 5 feet above bottom of bay and surface of grain. Bottom layer: Samples drawn between bottom of bay and point 5 feet above bottom.

[4] Average based on total weights.

Table 28.--Percentages of soybean and screenings in soybean samples drawn from the top and bottom layers in the hopper car after loading and before unloading at Minneapolis, Denver, and Omaha, by city, sampling sequence, and bay

[Data are averages of component weights drawn by 3 different probes]

City, sampling sequence, and bay[1]	Components in sample[2]			
	Top layer[3]		Bottom layer[3]	
	Soybean	Screenings	Soybean	Screenings
	Percent	Percent	Percent	Percent
MINNEAPOLIS-OUT				
Bay B.....	77.49	22.51	98.99	1.01
Bay C.....	77.09	22.91	94.03	5.97
Bay A.....	87.02	13.98	90.57	9.43
Average[4].....	79.53	20.47	94.97	5.03
DENVER-IN				
Bay B.....	73.74	26.26	98,78	1.22
Bay C.....	77.41	22.59	95.07	4.93
Bay A.....	89.09	10.91	91.72	8.28
Average[4].....	79.23	20.77	95.22	4.78
DENVER-OUT				
Bay B.....	87.71	12.29	97.94	2.06
Bay C.....	91.53	8.47	98.05	1.95
Bay A.....	92.05	7.95	97.41	2.59
Average[4].....	90.50	9.50	97.82	2.18
OMAHA-IN				
Bay B.....	87.57	12.43	98.29	1.71
Bay C.....	90.25	9.75	98.23	1.77
Bay A.....	93.37	6.63	97.96	2.04
Average[4].....	90.35	9.65	98.16	1.84
OMAHA-OUT				
Bay B.....	90.55	9.45	91.90	8.10
Bay C.....	93.91	6.09	92.45	7.55
Bay A.....	84.89	15.11	98.43	1.57
Average[4].....	89.76	10.24	94.22	5.78
MINNEAPOLIS-IN				
Bay B.....	88.46	11.54	90.87	9.13
Bay C.....	93.78	6.22	91.56	8.44
Bay A.....	98.75	1.25	98.54	1.46
Average[4].....	90.06	9.94	93.64	6.36

[1] Out: Samples were drawn from loaded car before it was moved out of city named. In: Samples were drawn before car was unloaded after arrival from another city. B, refers to brake end bay; C, center bay; A, alternate end (opposite brake end).

[2] Components of lot; soybeans, 95.12 percent; screenings, 4.88 percent.

[3] All samples in this table were drawn vertically at deepest part of bay. Top layer: Samples drawn between point 5 feet above bottom of bay and surface of grain. Bottom layer: Samples drawn between bottom of bay and 5 feet above bottom.

[4] Average based on total weights.

Table 29.--Percentage of components of wheat samples drawn by vertical and slanting probes from hopper car after loading and before unloading at Minneapolis, Denver, and Omaha, and difference between percentage of components of samples drawn by 3 probes and by all probes, by city and sequence of sampling

City and sampling sequence[1]	Wheat[2]				Corn[2]				Screenings[2]			
	Vertical probes[3]	All probes	Difference[4]	Slanting probes[3]	Vertical probes[3]	All probes	Difference[4]	Slanting probes[3]	Vertical probes[3]	All probes	Difference[4]	Slanting probes[3]
	Percent	Percent		Percent	Percent	Percent		Percent	Percent	Percent		Percent
Minneapolis--out.	88.48	89.07	0.59	89.59	4.94	4.45	-0.49	4.01	6.58	6.48	-.10	6.40
Denver--in.....	87.40	88.43	1.03	89.34	5.48	4.73	-0.75	4.06	7.12	6.84	-.28	6.60
Denver--out.....	91.03	90.21	-.82	89.39	3.96	4.01	.05	4.05	5.01	5.78	.77	6.56
Omaha--in.....	90.36	90.39	.03	90.42	4.09	4.06	-.03	4.02	5.55	5.55	.00	5.56
Omaha--out.....	90.75	90.51	-.24	90.26	4.12	3.70	-.42	3.27	5.13	5.79	.66	6.47
Minneapolis--in..	90.07	89.75	-.32	89.44	4.73	4.38	-.35	4.05	5.20	5.87	.67	6.51
Average.....	89.68	89.73	.25	89.74	4.56	4.22	-.34	3.91	5.76	6.05	.29	6.35
Standard deviation.....	1.43	.82	.....	.47	.60	.37	--	.31	.88	.50	--	.39
Coefficient of variation.....	1.59	.91	--	.52	13.16	8.77	--	7.93	15.28	8.26	--	6.14

[1] Out: Samples were drawn from loaded car before it was moved out of city named. In: Samples were drawn before car was unloaded after arrival from another city.

[2] Components of lot: Wheat, 90.27 percent; corn, 4.97 percent; screenings, 4.76 percent.

[3] Vertical probes: one probe sample drawn at deepest part of each bay. Slanting probes: one probe sample, slanting toward the end, drawn at each end of car, and one probe sample, slanting toward the side, drawn in each bay.

[4] Difference between percentages for vertical probes and for all probes.

Table 30.--Percentage of components of corn samples drawn by vertical and slanting probes from hopper car after loading and before unloading at Minneapolis, Denver, and Omaha, and difference between percentage of components of samples drawn by 3 probes and by all probes, by city and sequence of sampling

City and sampling sequence[1]	Corn[2]				Wheat[2]			
	Vertical probes[3]	All probes	Difference[4]	Slanting probes[3]	Vertical probes[3]	All probes	Difference[4]	Slanting probes[3]
	Percent	Percent		Percent	Percent	Percent		Percent
Minneapolis--out..	94.81	94.46	-.35	94.17	5.19	5.54	.35	5.83
Denver--in.....	95.36	95.16	-.20	94.18	4.64	4.84	.20	5.82
Denver--out.....	94.37	94.11	-.26	93.87	5.63	5.89	.26	6.13
Omaha--in.....	94.64	94.14	-.50	93.60	5.36	5.86	.50	6.40
Omaha--out.....	94.00	93.52	-.48	93.06	6.00	6.48	.48	6.94
Minneapolis--in...	93.94	94.00	.06	94.06	6.06	6.00	-.06	5.94
Average.....	94.52	94.23	-0.29	93.82	5.48	5.77	-0.29	6.18
Standard deviation	.54	.44	--	.43	.54	.44	--	.43
Coefficient of variation.....	.57	.47	--	.46	.99	.75	--	.70

[1] Out: Samples were drawn from loaded car before it was moved out of city named. In: Samples were drawn before car was unloaded after arrival from another city.
[2] Components of lot: Corn, 95.01 percent; wheat, 4.99 percent.
[3] Vertical probes: one probe sample drawn at deepest part of each bay. Slanting probes: one probe sample, slanting toward the end, drawn at each end of car, and one probe sample, slanting toward the side, drawn in each bay.
[4] Difference between percentages for vertical probes and for all probes.

Table 31.--Percentage of components of soybean samples drawn by vertical and slanting probes from hopper car after loading and before unloading at Minneapolis, Denver, and Omaha, and differences between percentage of components of samples drawn by 3 probes and by all probes, by city and sequence of sampling

City and sampling sequence[1]	Soybeans[2]				Screenings[2]			
	Vertical probes[3]	All probes	Difference[4]	Slanting probes[3]	Vertical probes[3]	All probes	Difference[4]	Slanting probes[3]
	Percent	Percent		Percent	Percent	Percent		Percent
Minneapolis--out...	90.18	93.41	3.23	96.39	9.82	6.59	-3.23	3.61
Denver--in.....	91.05	93.02	1.97	95.02	8.95	6.98	-1.97	4.98
Denver--out.....	97.07	94.63	-2.44	92.39	2.93	5.37	2.44	7.61
Omaha--in.....	97.77	94.62	-3.15	91.01	2.23	5.38	3.15	8.99
Omaha--out.....	95.36	94.13	-1.23	92.93	4.64	5.87	1.23	7.07
Minneapolis--in....	95.70	93.05	-2.65	90.49	4.30	6.95	2.65	9.51
Average.....	94.52	93.81	-.71	93.04	5.48	6.19	.71	6.96
Standard deviation	3.16	.75	---	2.29	3.16	.75	--	2.29
Coefficient of variation.....	3.34	.80	--	2.46	57.66	12.12	--	32.90

[1] Out: Samples were drawn from loaded car before it was moved out of city named. In: Samples were drawn before car was unloaded after arrival from another city.
[2] Components of lot: Soybean, 95.12 percent; screenings, 4.88 percent.
[3] Vertical probes: one probe sample drawn at deepest part of each bay. Slanting probes: one probe sample, slanting toward the end, drawn at each end of car, and one probe sample, slanting toward the side, drawn in each bay.
[4] Difference between percentages for vertical probes and for all probes.

Component estimates for the wheat and corn lots sampled by the two patterns showed little difference; however, the estimates for screenings in the soybean lot varied considerably. Generally, the components in the samples drawn by the vertical probing pattern were more nearly in agreement with the actual percentage of components in the lots than the components in samples drawn by the vertical-plus-slant probing pattern were. These data are quite limited, and firm conclusions cannot be made regarding the merits of the two probing patterns.

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